Linking the National Vegetation Classification System to NRCS Ecological Sites in Southeastern Montana

Prepared for the
Bureau of Land Management

By
Greg Kudray and Steve Cooper

Montana Natural Heritage Program
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June 2005

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Prepared for the
Bureau of Land Management State Office
Billings, Montana

Under Challenge Cost Share Agreement #
1422E930A960015

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Please cite this document as follows:

Kudray, G. and S. V. Cooper. 2005. Linking the National Vegetation Classification System to NRCS Ecological Sites in Southeastern Montana. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, MT. 18 pp. plus appendices.

Executive Summary

The two vegetation/site classifications that are widely used across the rangelands of the western United States and adopted by federal agencies are ecological sites (ecosites), developed by the National Resource Conservation Service (NRCS), and plant associations of the National Vegetation Classification System (NVCS), now maintained by NatureServe.

Ecosites are delineations of unique combinations of physical site variables within climatically/ geographically-defined ecoregions. A specific ecosite support a unique historic climax plant community (HCPC) with management/disturbance driven composition changes predicted by a state – and – transition model.

The National Vegetation Classification System is a hierarchical system initially developed by The Nature Conservancy but now managed by NatureServe with continuing refinement guided by the Vegetation Classification Panel of the Ecological Society of America. Vegetation structure defines the higher and more general levels while the finer levels, alliance and plant association (P.A.), are floristically defined.

One objective in this study was to associate NVCS P.As. with ecosites in the 10" – 14" precipitation zone of NRCS Major Land Resource Area 58A. This links the rich management and ecological information available for plant associations with mapped ecosites. Another objective was the establishment of permanent monitoring plots with data on baseline vegetation and environmental conditions for the major ecosites of the region

We assigned a P.A. and ecosite type to field collected plots and data from other studies in the study area. The first year of field data collection included mostly rapid assessment plots across the entire range of ecosites present. Comprehensive plots the next year focused on the major ecosite groups of sandy, silty, and clayey. Analysis of the combined data set included vegetation ordination, classification, tabular summaries, multi-response permutation procedure and indicator species analysis. We separated and independently analyzed data from the major ecosite groups. We also combined field plot data with historical plot data to construct ecosite – P.A. relationship tables.

Ecosites at the ends of the textural spectrum (sands and clays) have the least variable vegetation communities due to a reduced ecological niche but are still associated with several possible P.As. Shallow ecosites and ecosites defined by gravel tended to have especially variable vegetation characteristics; these plant communities tended to be more like those on ecosites with a similar textural matrix, e.g. shallow sandy sites were more like sandy ecosites than other shallow sites. We also found that the soil mapping in the sampled area tended to overestimate the acreage of shallow and very shallow types. Even with rock outcrops nearby, our soil pits were usually deeper than maximum bedrock depths allowed for the type definition.

Ecosites and P.As. are not simply associated, even though some ecosites, especially sandy and clayey ecosites, had strongly associated P.As. NVCS P.As. are a narrower concept than ecosites, which typically have several states (seral stages) in a state – and – transition model. Our resultant crosswalk reflected this with each major ecosite type linked with several P.As. The interaction of droughts, grazing (and associated water developments), fire, sagebrush control, invasive plants, small-scale topographic variations, plant species dynamics, and land use history influences vegetation patterns on any ecosite location. Some of these influences are also at a scale too small to be captured in typical soil mapping; a variety of P.As may occur within an ecosite map unit.

Large scale influences on ecosites and their vegetation communities are also important. The study area encompasses over 26.7 million acres. The roughly 30 common ecosites are generalizations of the entire range of soil texture, chemical, topography, and precipitation (within 10" – 14"), so we expected that there would be considerable variability in the vegetation communities present.

The interaction of all these factors creates the unique habitats and biodiversity that make prairie ecosystems so biologically important. However, knowing the characteristics of reference condition vegetation communities in any area is difficult since grazing can be a dominant influence and a well distributed system of exclosures across major ecosites is lacking. Having a network of exclosures will help provide baseline data for monitoring similar ecosite types.

We established 58 permanent monitoring points on a variety of ecosites. A program of periodically monitoring these and comparable exclosures every 5 – 10 years will help detect transitions in vegetation response to climate and management.

Acknowledgments

Bill Volk from the Montana BLM State Office was instrumental in initiating and supporting this project. We are very grateful to Roxanne Falise and Teresa Hanley, also at the State Office, for their support. Robert Mitchell, Louise de Montigny, Dale Tribby, and others at the BLM Miles City Field Office helped us with logistics and their considerable local knowledge. Bob Leinard and Sue Noggles from the NRCS gave freely of their time to help us better understand ecological sites. In our office, we are grateful for the help Allan Cox gave us with maps and Pam Chriske with production of the final report.

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INTRODUCTION

A site classification incorporating vegetation characteristics is an essential tool for informed land management. Vegetation-based site classifications have been a staple of management since the late 1800's (Pfister 1989). There has been considerable activity by public agencies within the US in the last few decades to produce land classification systems applicable regionally or across the nation.

Among the many vegetation and site classification systems that developed over the years, two are widely used across the rangelands of the western United States and adopted by federal agencies. The National Resource Conservation Service (NRCS) system is based on ecological sites (ecosites, formerly range sites), which are delineated by unique combinations of physical site variables within ecoregions. These ecosites support a unique historic climax plant community (HCPC). The HCPC serves as a reference point to which seral stages can be compared. This site classification system incorporates the non-equilibrium state-and-transition models developed for arid and semi-arid rangelands with seral stages incorporated in ecosite models.

The National Vegetation Classification System (NVCS) (Grossman et al. 1998) represents another approach adopted by many public agencies and is applicable to any landscape/ecosystem within the U.S. The Federal Geographic Data Committee (FGDC) has accepted this framework as a standard for all federal agencies (FGDC 1997). The NVCS was originally developed by The Nature Conservancy and now is primarily managed by NatureServe with additional input from the Ecological Society of America's Vegetation Classification Panel (Jennings et al. 2003), Natural Heritage programs and many others.

The NVCS is a hierarchical approach based on existing vegetation with physiognomy more important at broader levels and composition emphasized at the finest levels of alliance and association. Specific association types are primarily based on vegetation plots from published studies and other research work; thousands of associations have been named and described, although a reduced number of associations have been described in a standardized manner as proposed by the ESA Vegetation Panel (Jennings et al. 2003). This system can be used for vegetation mapping and inventory (Grossman et al. 1998); however, difficulties remain, especially in classifying successional vegetation (treating seral stages as part of potential natural vegetation units versus naming/describing each seral stage as a unique association).

Ecological sites are essentially mapped by the NRCS in county soil surveys through an association of map units with one or more ecosites. Their incorporation of the widely adopted state-and-transition models along with detailed vegetation composition and production data allows managers to evaluate rangeland condition and restoration potential. Ecosite descriptions offer considerable information but are not linked to NVCS types, which form a rich source of complementary information. The mapped nature of ecological sites would also allow a direct application of NVCS types to land management if the systems were associated. In the future, users of these respective systems should be able to communicate about lands under their jurisdiction and management. To do so, a correspondence will have to be established between the basic units of each system.

The purpose of this study is to relate the Montana Natural Heritage Program NVCS plant associations of NRCS Land Resource Area 58A (Sedimentary Plains, East; 10” – 14” precipitation range) located in southeastern Montana with ecosites. The primary focus is on the dominant ecosites in the regions, clayey, silty, sandy, and sands. Another objective was to establish permanent monitoring plots at sites with vegetation in good ecological condition.

Ecological Sites and NVCS Plant Associations

An ecosite is a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation (USDA NRCS 2003). It possesses a set of key distinguishing features including characteristic soils and vegetation, that are a product of all the environmental factors responsible for their development; the factors are the same as described by Major (1959) and Jenny (1961): parent material, climate, living organisms, topography or landscape position and time. A characteristic hydrology also develops over time, influenced by the soil and plant community.

The plant community on a specific ecosite has an association of species that differs from that of other ecosites in the kind and/or proportion of species, or in total production (USDA NRCS 2003). Ecosites are derived and apply to a given land resource unit (LRU) as delineated by the NRCS (comparable to ecoregions as defined by the U. S. Forest Service and others). These units are areas of similar geology, landform, soil, vegetation, and climate.

At the time of European immigration and settlement, there existed historic climax plant communities (HCPC) (USDA NRCS 1997). Essential to the development and maintenance of these plant communities were natural disturbances including fire, drought, native fauna grazing, and insects. The effects of these disturbances are apparent in the variable characteristics of a site and establish the boundaries of its dynamic equilibrium.

The association is the finest level in the NVCS hierarchy and is the basic unit for vegetation classification in North America; it forms a plant community type of definite floristic composition, uniform habitat conditions, and uniform physiognomy (Grossman et al. 1998). The NVCS recognizes that plant associations (or communities) can occur at multiple spatial scales depending on the steepness of environmental gradients and the patterning of disturbance processes across the landscape. In addition, the same association can occur at different scales under different environmental and disturbance conditions (Grossman et al. 1998). This means 1) that the NVCS accepts compensating factors as explaining why some plant associations can exhibit a broad distribution across regions and 2) that the NVCS is a classification of existing vegetation and two stands could be placed in different associations even though they could both belong to the same potential natural vegetation association.

The HCPC as recognized by the NRCS is a more broadly defined entity than a NVCS plant association despite the similarity in their respective definitions. The HCPC of an ecosite is not a narrowly fixed assemblage of plant species for which the species proportions are the same across years or locations. Some have a large range of variation, others a small range. Plant communities subjected to abnormal disturbance (intensity, duration or type) or shielded from natural perturbations such as fire and grazing for extended periods will diverge from the HCPC (USDA NRCS 1997).

Rangeland Vegetation Change: Ecological Sites and the State and Transition Model

Although range managers have long recognized that rangelands can be transformed, e.g. from grasslands to shrublands that cannot be returned to grassland by grazing management (Laycock 1991), the historic view has been the succession – retrogression (range condition) model of Dyksterhuis (1949) based on the successional theory of Clements (1916) and polyclimax concepts of Tansley (1935). This model suggests that a competition-mediated climax state will result with time, regardless of the disturbances (Westoby 1980).

The new paradigm for range management termed the state–and–transition model (ST) recognizes 1) mechanisms other than competition determine community patterns and structure, 2) the multi-equilibrial nature of many rangeland ecosystems and 3) the rapid and unanticipated shifts among these equilibria (Westoby et al. 1989). Practitioners of the ST model anticipate departures from the monoclimax model and incorporate this into management plans. This model is the approach used by the Society for Range Management (1995) and USDA Natural Resources Conservation Service (1997) The ST models are coupled to ecosites and Land Resource Units (LRU) in that a particular model applies to one ecosite within only one LRU (Bestelmeyer et al. 2003).

Development of the Montana NVCS

It is a goal that Natural Heritage programs have a vegetation classification for their state and that a national classification develops from these state classifications (Grossman et al. 1998). States develop these classifications in a variety of ways. A typical beginning was a list of plant communities/associations derived from literature sources. In some cases, these compilations were published in refereed journals (see Bourgeron et al. 1988), but beyond compiling a list of types and supporting (often annotated) literature, “working classifications” were not immediately constructed. By “working classification”, we mean an effort to produce a key and detailed descriptions of the vegetation units.

A later development was the convening of Heritage Program ecologists from throughout a region with ecologists associating each putative plant association with ecoregions (Bailey 1976, Avers et al. 1994) where it occurred. Since ecologists had only association names and not always descriptions to base their assignment of types to ecoregions the outcome of this process was approximate. A database called EcoART (NatureServe 2003) was populated with this distribution information along with detailed floristic and ecological information. Eventually managed by NatureServe, EcoART has become the authority for relating the distribution of plant associations to ecological as well as administrative boundaries.

At the time of compiling Montana’s list of plant associations (late 1980’s) there existed eight working classifications in Montana all based on Daubenmire’s (1966) habitat type concept; Pfister et al. (1977) for largely USFS managed forested lands, Mueggler and Stewart (1980) for rangelands primarily west of the Continental Divide, Hansen and Hoffman (1987) for southeastern Montana and adjacent Forest Service lands in North and South Dakota, Cooper and Pfister (1981, 1985) for the Blackfeet and Northern Cheyenne/Crow Reservation forested lands respectively, and Roberts et al. (1979) and Roberts (1980) for the forested portion of the Bear’s Paw Mountains, Little Rocky Mountains and the Missouri River Breaks. Since that time five more first approximation working classifications have been developed for Montana; Cooper et al. (1995) for all vegetation types in a portion of southwestern MT, Vanderhorst et al. (1998) for Carter County, DeVelice et al. (1995) for the northeastern portion of the state, and DeVelice and Lesica (1993) for the Pyror Mountains and adjacent Wyoming Basins Section.

All these works derived their classifications by sampling relatively undisturbed, late seral to putative climax vegetation; these basic units were termed habitat types or potential natural vegetation (PNV) plant associations. Only two Montana works have approached the challenge of classifying seral and disturbed vegetation types to produce an existing vegetation type classification, which is the goal of the NVCS (Hansen et al. 1995 for all of Montana’s wetland and riparian vegetation and a NatureServe work in progress for Glacier-Waterton Lakes International Peace Parks). Many relatively recent reports (authored after most of the above-cited references were published) describe new plant communities/associations (see Cooper 2003, Heidel et al. 2001, Cooper and Jean 2001, Cooper et al. 2001).

Methods

In 2003, we sampled a wide variety of ecosites on BLM managed land throughout LRU 58A in the 10” – 14” precipitation zone (Figure 1). Some plots were slightly outside of these areas. Plot selection focused on sites with the vegetation in good condition. We used soil survey maps to ensure that most ecosite types were represented. We sampled some plots using standard Montana Natural Heritage community survey methods with detailed vegetation and abiotic sampling. We also used a rapid assessment sampling procedure to sample a greater number of plots and ecosites across this large region. The standard community methods are detailed below; the rapid assessment method included listing the top five plant species by cover and verifying the ecosite with a soil pit.

The 2004 field sampling also occurred on BLM managed land with vegetation communities in good condition. There was an additional focus on the most common ecosites: Silty (Si), Sandy (Sy), Sands (Sa), Clayey (Cy). We selected plots from a BLM effort at inventorying range site condition during the late 1970’s and early 1980’s called the Soil – Vegetation Inventory Method (SVIM). They established sampling transects throughout Montana and identified range condition (excellent through poor) associated with each site. From archived SVIM records we were able to determine, based on both the judgment of the original sampling team and our inspection of their vegetation data, what sites were in excellent to good condition (at the date of sampling). The SVIM sampling methodology involved long transects with associated subplots; transects often crossed more than one ecosite but vegetation data and condition were not kept separate by ecosite. This sampling methodology and the time elapsed limited the usefulness of the data since there could be significant differences in vegetation condition across the several hundred meter length of the transect and sites in good condition 20 – 30 years ago were either no longer in that condition or difficult to locate along the transect.

While most revisited SVIM areas were not suitable for our purposes, we did sample and permanently mark 58 plots with vegetation in good to excellent condition. We marked each of these plots with a steel rerod driven into the ground at plot center, approximately 20 – 30cm was left exposed, painted fluorescent orange then topped with a plastic yellow cap. Standard Montana Natural Heritage Community survey methods were used to collect a variety of abiotic and biotic data including vascular plant species with cover values by classes in a circular plot size of 400 m^2 (11.28 m radius, about 1/10 acre), ground cover by classes, slope, aspect and other data. Plot area was scaled back or changed in shape if sites were not homogenous abiotically; never was the area less than 200 m^2.

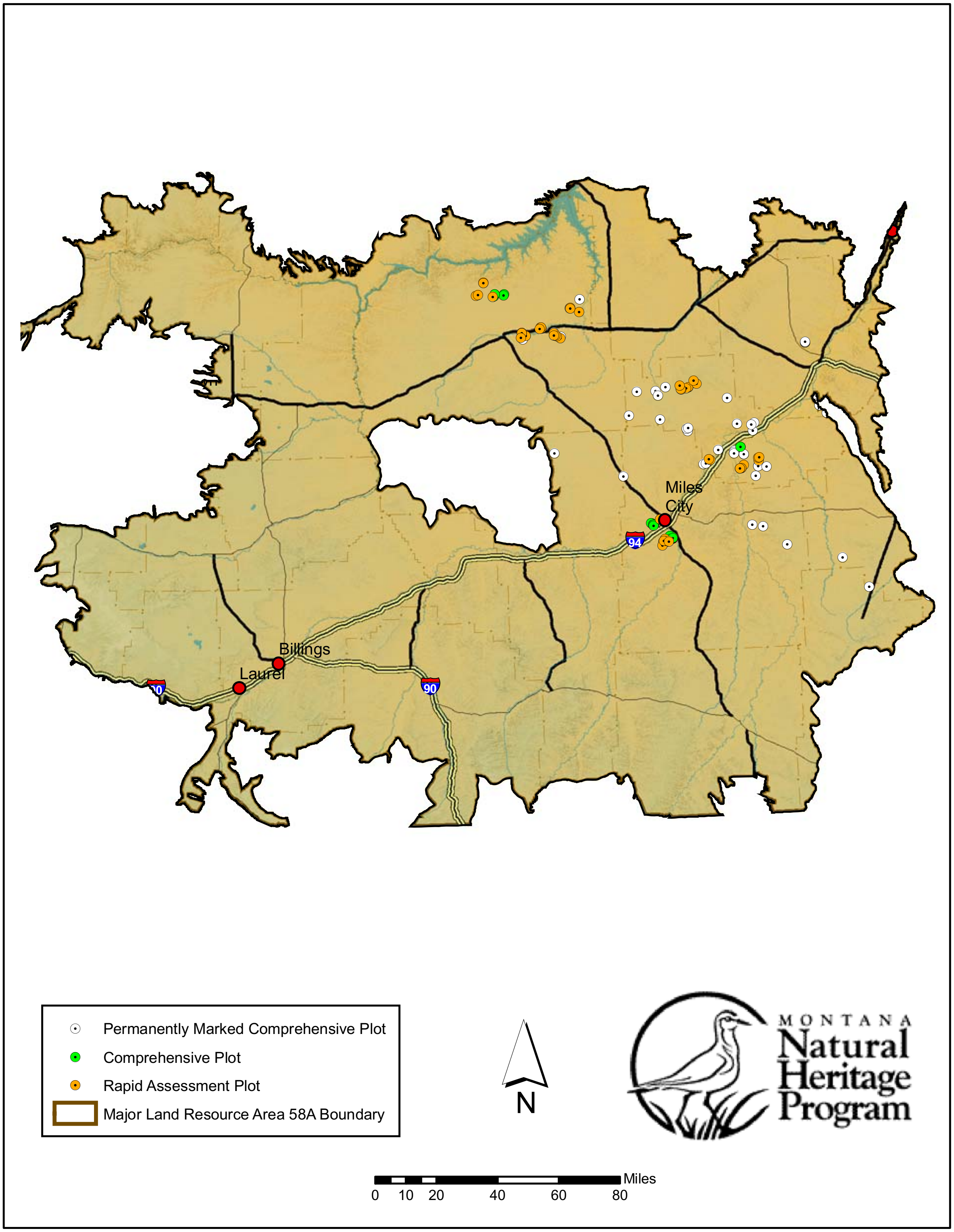
A soil pit was dug to a depth of at least 20 inches to determine ecosite and a composite soil sample was extracted from the upper 10 cm of the profile from 4 representative locations in the plot. The Montana State University Soils Laboratory analyzed each soil sample for percent sand, silt and clay, as well as pH, conductivity and organic matter. We identified all plots to ecosite type by following the dichotomous key “Montana, Key for Ecological Sites” (USDA NRCS 2000). We determined the NVCS plant association for each plot.

We also compiled a database of plots of sites in good ecological condition. Plots collected by previous studies in LRU 58A and adjacent areas include those by Hansen and Hoffman (1987), Heidel et al. (2001), and Vanderhorst et al. (1998). Data entered included quantitative cover estimates and abiotic site variables necessary to determine ecosite.

Data Anaylsis

Two main data sets were developed based on the different sampling intensities: comprehensive and rapid assessment (RA). The comprehensive data set focused on the major ecosite types (sands, sandy, silty, and clayey). It included a complete list of plant species and soil data. These 32 plots containing 52 plant species were reduced to data set of 29 plots with 49 species after an analysis with the software program Pc-Ord (McCune and

Figure 1. Map of study area and plot locations.



Grace 2002). Species that only occurred in one or two plots were eliminated and three plots identified as outliers were removed. A second data matrix contained soil variables for each plot. The soil electrical conductivity variable was highly skewed so it was log-transformed before analysis. Nonmetric multidimensional scaling (NMS) was the ordination process used to assess the similarity of vegetation plots (McCune and Grace 2002). This technique orders plots (and species, if desired) along axes that can be examined for any patterns. Soil characteristics were associated with vegetation patterns by correlating soil variables with the axes of the ordination. A multi-response permutation procedure (MRPP) tested for significant vegetation differences among the four ecosite groups; this analysis also indicates the within-group dispersion.

The RA data set included a wide range of ecosite types. The comprehensive plots were recoded to match the dominance rank system of the RA plots and incorporated into the data set. Only one plot, a saline upland with unique vegetation, was eliminated as an outlier, 125 plots with 53 species remained. We used NMS to ordinate this data and cluster analysis to hierarchically split the vegetation data into progressively finer groups of plots with similar vegetation. Hierarchical clustering does not automatically determine the number of clusters that are interpretable. Indicator species analysis (ISA) was used to provide an objective criterion for making that determination. ISA identifies species that are strongly associated with individual clusters. Each species receives an indicator value based on its abundance and frequency of occurrence within clusters. Monte Carlo tests are then used to test the strength of these associations. ISA was repeated for each level of clustering. We determined the most ecologically meaningful number of clusters with a technique advocated by McCune and Grace (2002) that chooses the number of clusters with the most robust indicator species indicates. We used this optimal grouping to associate the primary indicator species for each of the clusters to NVCS plant associations.

We separated silty ecosite plots from the RA data set to explore vegetation patterns within that group. We eliminated three outliers from the data set, which then included 33 plots and 35 species. Scores from a NMS ordination were correlated with individual plant species to elucidate vegetation patterns. We followed the same procedure with a sand and sandy ecosite group (16 plots and 27 species) and a clay, dense clay, and claypan ecosite group (30 plots and 23 species).

RESULTS

Main Ecosite Types (Comprehensive Data Set)

The four main ecosite types (sands, sandy, silty, and clay) showed different patterns in the vegetation ordination. Clay and sand ecosites have relatively tight groups indicating lower variability in vegetation composition/cover within groups. More vegetation variation is apparent in the sandy and silty plots with widely scattered plots across ordination space. The MRPP also indicated a similar pattern with the following average within group distances: sands (47.7), clayey (48.2), sandy (62.4), and silty (64.3). The MRPP results also verified significant differences among the four groups tested ($p = .014$).

Correlation values between the two primary vegetation ordination axes show that the only strong vegetation – environment relationship in this data set was with sand and clay content. Axis 1 (40.4%) and axis 2 (30.2%) explained a total of 70.6% of the variation present in the vegetation data set. Only sand and clay content were correlated with Axis 1 at a minimum r level >.2. No soil factors were even moderately correlated with axis 2.

Indicator species analysis identified the affinity of plant species for a particular ecosite type. The small number of plots in some ecosites, four each in sands and sandy ecosites, make strong conclusions impossible but some species affinities are apparent. Table 1 lists significant indicator species.

Rapid Assessment Data

This vegetation data set included 14 different ecosite types. The NMS ordination axes explained 80% of the variation in the data set; axis 1 (24.4%) and axis 3 (39.1%) were most explanatory. The ISA technique identified nine clusters as the most ecologically optimal number. Some of the clusters consisted of plots in the same or closely related ecosite groups while other clusters were composed of a wide variety of ecosites (Table 2). Similarly, many ecosite plots were broadly distributed across several vegetation clusters.

Vegetation plots did not cluster well into groups that could be strongly associated with their respective ecosites (Table 2). Only a few clusters of the ecologically optimal nine clusters represent plots unequivocally associated with ecosite groups. Eight of the nine groups had at least five plots from various ecosites. Plots of a certain ecosite were similarly dispersed, for example, the 36 silty plots were placed in eight different cluster groups. The shallow and gravel ecosite groups had particularly variable vegetation and cluster membership. These

Table 1. Indicator species with p significance values <0.1 and associated ecological site.

Indicator Species	**Ecological Site Type**	**Significance value (p)**
Pacific wormwood *Artemisia campestris*	Sands	0.016
Sun Sedge *Carex inops*	Sands	0.027
Dragon wormwood *Artemisia dracunculus*	Sands	0.032
Prickly pear *Opuntia polycantha*	Silty	0.044
Western wheatgrass *Pascopyrum smithii*	Clayey	0.049
Brittle prickly pear *Opuntia fragilis*	Sandy	0.06
Wavy-leaved thistle *Cirsium undulatum*	Sandy	0.085
Needle-and-thread *Hesperostipa comata*	Sandy	0.088

Table 2. Cluster analysis of rapid assessment vegetation plots by ecological site membership.

Cluster #	**# of Plots**	**Sands (Sa)**	**Sandy (Sy)**	**Thin Sandy (Tsy)**	**Silty (Si)**	**Thin Silty (Tsi)**	**Clayey (Cy)**	**Thin Clayey (Tcy**	**Clay Pan (Cp)**	**Dense Clay (Dc)**	**Overflow (Ov)**	**Shallow (Sw)**	**Very Shallow (Vs)**	**Shallow Clay (Swc)**	**Gravel (Gr)**
1	6	3	3												
2	13	1	2	2	6					1					1
3	13				3		5		1		2	1			1
4	19		3		10							2	1		3
5	26		1		8		5	1	6	1	3		1		
6	10				4	1	2		1			1			1
7	15		3	3	3	1						3			2
8	12				1	2	7	1	1						
9	11				1	1		3				2	3	1	
Total	125	4	12	5	36	5	19	5	9	2	5	9	5	1	8

plots tended to have vegetation that was more similar to ecosite plots having similar textures, e.g. a sandy loam textured shallow ecosite would group with sandy ecosite plots not with other shallow plots. The ends of the textural range, sand and clayey ecosites, had more consistent plant species groups within each ecosite. Table 3 lists indicator species associated with the clusters. Ordination and correlation results of ecosite groups are summarized in Tables 4 – 6.

Database Analysis

A similar vegetation association – ecological site relationship was evident in an analysis of past MTNHP and USFS plots (Appendix C Tables 1 and 2). Generally, ecological sites with soils at textural extremes (sand or the clay group of ecological sites) had more consistent plant association groups while there was greater variability with other ecological sites. However, even the sand and clay groups had numerous plant associations recorded as occurring on each site type. Many plant associations have not been sampled and correlated to ecological site within the study area (Appendix C Table 2), even though this table reflects a broader area,

Some of these plots and associated types may occur outside of the 10” – 14” range our study focused on. The associations include forest (7), woodlands (17), shrublands (19), shrub herbaceous (17), dwarf-shrubland (7), herbaceous (51), and sparse vegetation (3). Only a limited number of these plant associations were actually encountered and sampled by MTNHP or USFS ecologists; 3 of 7 forest types, 10 of 17 woodland types, 3 of 19 shrublands, 8 of 17 shrub herbaceous types, 2 of 7 dwarf-shrublands, 25 of 40 herbaceous types and 2 of 3 sparse vegetation types.

Based on fieldwork conducted by the MTNHP and Jensen et al. (1992) a number of additional vegetation types not listed in EcoART were identified and sampled within the ecoregion (noted in Appendix C Table 1); these additional vegetation types included 3 forest, 3 shrub herbaceous, 10 herbaceous and 2 sparse vegetation types. In addition, a survey of permitting reports by consulting firms (e.g. Western Technology and Engineering, Inc. 1991) indicated there were additional unique types for this ecoregion not found in EcoART or identified in MTNHP/USFS sampling.

The correspondence between NVCS plant association and their fidelity to ecological sites is listed in Table 7 for the most common s encountered. The most common P.A., Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*)/Western wheatgrass (*Pascopyrum smithii*), occurred on 5 distinct Ecological Sites although all of these sites were deep soils with finer textures than those of Sandy or Sands ecosites. The little bluestem (*Schizachyrium scoparium*) – grama (blue *Bouteloua gracilis*, sideoats *Bouteloua curtipendula*) – threadleaf sedge (*Carex filifolia*) P. A. occupies sites at the coarser end of the soil textural range, but still overlaps considerably with about a third of the samples occurring on silty soils.

A similar lack of fidelity is apparent for all these common types. Overall, while soil characteristics and the corresponding ecological site type are important in a general sense, it is also clear that soil is not an absolute determinant of vegetation composition, a result similar to the ordination and classification data described in the preceding section.

DISCUSSION

Ecological Site Textural Groups

This analysis provides useful insight into the nature of prairie vegetation communities and environmental factors. Variability (diversity) is common but strong associations are also apparent in the linkage of NVCS plant communities with ecological sites, especially at the textural extremes (sands and clays) of site conditions. Less variability at these extremes is attributable to the narrowed ecological niche available to plant species. More species can establish in the broader mid-range of ecological sites, creating a diversity of plant community types.

Table 3. Indicator species associated with clusters of rapid assessment vegetation plots. Value is % of perfect indication, based on combining values for relative abundance and relative frequency.

Cluster #	**Indicator Species (Value)***		
1	Purple three-awn *Aristida purpurea* (57%)	Prairie sandreed *Calamovilfa longifolia* (47%)	Needle-and-thread *Hesperostipa comata* (26%)
2	Fringed sagebrush *Artemisia frigida* (27%)	Needle-and-thread (25%)	Threadleaf sedge *Carex filifolia* (23%)
3	Western wheatgrass *Pascopyrum smithii* (26%)	Kentucky blue grass *Poa pratensis* (21%)	3 species (15%)
4	Needle-and-thread (26%)	Blue Grama *Bouteloua gracilis* (25%)	Japanese brome *Bromus japonicus* (16%)
5	Western wheatgrass (29%)	Curly bluegrass *Poa secunda* (17%)	Prickly pear *Opuntia polyacantha* (16%) Japanese brome (16%)
6	Wyoming big sagebrush *Artemisia tridentata* ssp. *wyomingensis* (34%)	Blue Grama (22%)	Threadleaf sedge (17%)
7	Little bluestem *Schizachyrium scoparium* (34%)	Threadleaf sedge (27%)	Soapweed yucca *Yucca glauca* (18%)
8	Wyoming big sagebrush (35%)	Western wheatgrass (27%)	Blue Grama (14%)
9	Bluebunch wheatgrass *Pseudoroegneria spicata* (58%)	Ill-scented sumac *Rhus trilobata* (36%)	Little bluestem (26%)

Table 4. Results of NMS vegetation ordination of silty ecosites and the strongest correlations of species with axes.

Ordination Axis (r value)	**Species Correlations (r value)**		
Axis 1 (17.7%)	Blue grama (-.728)	Wyoming big sagebrush (-.602)	Prickly rose *Rosa acicularis* (-.588)
Axis 2 (34.4%)	Western wheatgrass (.793)	Blue grama (.542)	Dandelion *Taraxacum officinale* (.496)
Axis 3 (15.8%)	Threadleaf sedge (.763)	Blue grama (-.729)	Western wheatgrass (-.652)
Total Variation Explained (67.9%)			

Table 5. Results of NMS vegetation ordination of clay, dense clay, and claypan ecosites and the strongest correlations of species with axes.

Ordination Axis (r value)	Species Correlations (r value)		
Axis 1 (41.0%)	Wyoming big sagebrush (-.734)	Western wheatgrass (.717)	Silver sagebrush *Artemisia cana* ssp. *cana* (.608)
Axis 2 (33.4%)	Blue grama (-.707)	Cheatgrass (.595)	Wyoming big sagebrush (-.545)
Axis 3 (8.2%)	Axis variation is too low to allow for meaningful interpretation		
Total Variation Explained (82.6%)			

Table 6. Results of NMS vegetation ordination of sand and sandy ecosites and the strongest correlations of species with axes.

Ordination Axis (r value)	Species Correlations (r value)		
Axis 1 (43.3%)	Threadleaf sedge (-.732)	Soapweed yucca (-.680)	Prairie sandreed (.600)
Axis 2 (17.0%)	Needle-and-thread (-.777)	Soapweed yucca (.737)	Purple three-awn (-.593)
Axis 3 (27.7%)	Blue grama (.702)	Western wheatgrass (.584)	Little bluestem (-.485)
Total Variation Explained (87.9%)			

Table 7. Plot distribution of common NVCS plant associations on ecological sites.

NVCS Plant Association	Number of plots	Number of ecological sites
Wyoming big sagebrush/Western wheatgrass shrub herbaceous vegetation	31	5
Silver sage/Western wheatgrass shrub herbaceous vegetation	12	3
Western wheatgrass/Needle-and-thread central mixedgrass herbaceous vegetation	15	3
Little bluestem – grama (blue, sideoats) – threadleaf sedge herbaceous vegetation	22	6
Western wheatgrass – green needlegrass herbaceous vegetation	14	4
Needle-and-thread –blue grama – threadleaf sedge herbaceous vegetation	26	5

While some of the lack of plant association fidelity to soil texture and ecosite may be attributed to differential disturbance impacts, there is also evidence of a generally wide range of ecological amplitude in these mixed-grass vegetation associations. The western wheatgrass – green needlegrass (*Nassella viridula*) P. A. very likely occurs on sites with low grazing impact (both dominant/indicator species being highly preferred forage) and could therefore be considered as close to HCPC as any community in our matrix. However, it also spans a wide textural range from soils high in clay (clayey ecosite) to those with low clay and moderately high in sand (sandy ecosite), although nearly half the samples came from Silty ecosites.

The most common clayey, sandy, and silty ecological site types targeted for more intensive sampling contained a wide variety of plant associations (21, 14 and 21 plant associations each, respectively). Part of this variety is due to productivity and succession/disturbance influences that result in a variety of physiognomic classes. Clayey ecosites range from forests and woodlands to shrublands, dwarf-shrublands, herbaceous, and even sparse vegetation plant associations. Silty ecosites are almost as diverse with woodlands, shrublands, shrub herbaceous, and herbaceous (with both cool-season and warm-season graminoids dominant) represented. Even for ecosites with a relatively narrow range of abiotic site parameters, e.g. Sands, the range included 8 plant associations and 3 structural types. Part of this variability is inherent in the hierarchical nature of the NVCS where a physiognomic level in the classification structure means that succession by woody species can result in an entirely new P.A.. Variability is also due to the somewhat broader range of ecological conditions represented in our database analysis.

<u>Silty Ecosites</u>

Components

Silty, thin (or steep) silty (types sampled are in bold)

Landscape setting

There are large expanses of this most common type found on sedimentary plains and other landforms throughout the region.

Vegetation Analysis and Interpretation

Species correlations with ordination axes for silty ecosites (Table 4) show patterns related to ecological site factors, grazing regimes, and other disturbances. Overall, there is considerable unexplained variability with the ordination only accounting for about 68% of the overall vegetation pattern. The abundance or lack of blue grama and threadleaf sedge, considered grazing increaser species, and their strong correlations with vegetation patterns suggest that grazing is a major determinant of vegetation composition and abundance. The total lack of more palatable grazing species in this table (e.g. green needlegrass) also supports grazing as an overwhelming influence on vegetation. Grassland vegetation responds to grazing in several ways. Some palatable species decrease in cover or virtually disappear while other less-palatable species increase. Bare ground establishment sites can increase with hoof disturbance or erosion allowing more resistant species to reproduce and succeed.

Wyoming big sage also strongly correlates with vegetation patterns. While sometimes considered an increasing species under heavy grazing, it has also been actively controlled in the past because of a belief that grass production will increase with sagebrush eradication. Wyoming big sage is slow to respond to wild or prescribed burns and may take decades to reoccupy a site.

Slope, aspect and topographic position are strong determinants of moisture status; these environmental attributes have long been associated with vegetation patterns in grasslands. Although sites with slopes >15% fall into a different ecosite, there is a continuous relationship operating throughout the range of possible slopes. Threadleaf sedge is more resistant to erosion than some other species, which will help it succeed even on these flatter sites. Positions high on the landscape, even if flat, often have a vegetation community different from sites lower with similar soils. Aspect relates to insolation and moisture relations; there is a corresponding change of vegetation communities with aspect and landscape position.

Clay Ecosites

Components

Clayey, **steep (or thin) clayey**, **dense clay**, **shallow clay**, **clay pan**, shale, badlands and coarse clay (types sampled are in bold)

Landscape setting

Clayey ecological sites are common and widely distributed throughout the study area. There are two general landscape settings, lower sedimentary formations (typically) and small and relatively uncommon eroded shale highlands.

Vegetation Analysis and Interpretation

The ordination of clayey plots explains almost 75% of the variation in the data set with only two axes (Table 5). The lack or abundance of silver sage and Wyoming big sage dominate the first axis. In the study area, silver sage was generally in a lower landscape position with more moisture availability than Wyoming big sage sites. Some of these sites are probably similar to overflow sites although they lack enough overflow characteristics to be mapped as such in the soil surveys. Overall, this pattern probably reflects a moisture gradient in addition to the same factors discussed above regarding sagebrush establishment, presence, and site disturbance. Disturbance and subsequent non-native weed invasion are also reflected in the presence of cheatgrass as a strong correlate with axis 2.

The relationship of plant associations to ecological sites can similarly be viewed as two groups defined by the dominance of sage. There were six sage P.As. sampled that, if without sage, would be similar to corresponding, mostly western wheatgrass, herbaceous types. The absence of sage can be due to human control, wildfire (Wyoming big sage recovers slowly after fire), or other factors but site factors are not typically determinant. Western wheatgrass, threadleaf sedge, and blue grama are the most common herbaceous species on these sites. Their relative dominance is often grazing related. Threadleaf sedge and blue grama tend to increase with more grazing pressure. Western wheatgrass will increase with less grazing and on more mesic sites. The western wheatgrass association represents the mesic extreme of these sites, which often have supplemental moisture. One plant association, western wheatgrass – green needlegrass, was recorded for these ecological sites in the database but never sampled. Green needlegrass is very palatable and not a codominant on any sites where widespread grazing is permitted.

Few steep clay or shallow clay types were sampled but tended to have vegetation that reflected the topographic position more than the clay texture. Species that never occurred in typical lower landscape clayey sites like little bluestem became common and the vegetation was generally much sparser. The influence of landscape position on the moisture regime is probably an important vegetation determinant along with the greater erosion and higher shale fragment content present at these sites.

Sandy Ecosites

Components

Sands, **sandy**, **steep (or thin) sandy** (types sampled are in bold)

Landscape setting

Sandy ecosites are relatively common throughout the study area but less common than the clay or silt groups. There are two general landscape settings; sedimentary plains and highlands with resistant sandstone outcrops and their adjacent depositional areas.

Vegetation Analysis and Interpretation

Vegetation patterns of sand and sandy ecosite plots were explained better in the ordination than any other ecosite group (Table 6). Axis 1 reflects sites dominated either by prairie sandreed (*Calamovilfa longifolia*) or by threadleaf sedge (and soapweed yucca *Yucca glauca*). Both of these rhizomatous graminoids are strong competitors that, once established, can largely exclude many other species. Soapweed yucca and threadleaf sedge are also typically dominant on steeper eroded sites. The vegetation pattern corresponds to the two quite different landscape settings for sandy ecosites.

The species strongly correlated with axis 3 may relate to the range of soil textures found. The textural differences between sands and sandy ecosites was often minimal with correspondingly close vegetation associations, but other non-characteristic species did occur on some sites. For example, Western wheatgrass and blue grama are more characteristic of finer soils and likely represent the extreme end of textures that constitute sandy ecosites, possibly in combination with other site factors related to moisture regimes. This axis may also relate to landscape position since little bluestem occurs on slopes or higher on the landscape.

The influence of grazing on vegetation composition did not generally seem as important as landscape position and plant species dynamics. Higher landscape positions have several factors that likely play a role in structuring plant communities including a poorly developed soil with more soil fragments and coarser textures, quicker precipitation run-off, and often less grazing due to water availability. Patchy vegetation patterns were especially apparent on these sites, possibly due to the loose soil and subsequent ease of dominance by rhizomatous graminoids.

Plant associations corresponded to these influences. Prairie sandreed associations reflected areas with a rhizomatous species dominance. Soapweed yucca and little bluestem association are strongly associated with higher landscape positions. Needle and thread (*Hesperostipa comata*) dominated associations represent the finer end of the sandy soil spectrum.

Ecological and Cultural Influences on Prairie Vegetation

The study area encompassed over 26.7 million acres, classified into only about 30 ecological sites, many of which are relatively minor. There are numerous environmental and cultural factors influencing vegetation across such a vast area. A precipitation range of 10” – 14” is considerable and topographic considerations magnify this difference. Aspect, slope, and small-scale topographic patterns resulting in concentrated or diffused runoff all interact to create a considerable moisture gradient. Equally critical are cultural influences. Grazing is extremely temporally and spatially variable with considerable long-term effects on vegetation. Past grazing regimes have lasting legacies if state and transition boundaries are breeched and the vegetation undergoes a transition that creates a near permanent disclimax community. The BLM lands sampled also have a unique land use history that may not be totally reflective of the vegetation – ecological site relationship across all ownerships in the ecoregion

Prairie ecosystems evolved with drought and disturbance from wildfire and wildlife. The nature of wild ungulate grazing is fundamentally different from domestic stock impacts – typically more concentrated but with longer rest periods. Water locations are critical; the vegetation in upland areas far from water likely had a considerably different disturbance regime than locations near permanent streams. Water developments have undoubtedly affected historic plant community dynamics. Many sites evaluated as good to excellent in the SVIM assessment were revisited and found in poorer condition due to water developments and subsequent concentrations of stock. Wildfire or prescribed burns have considerable impacts on vegetation communities. The historic fire regime has been altered with largely unknown affects. Woody species have expanded along with correspondent vegetation community change. We have had a multi-year drought in this area; these periodic droughts are normal but can have considerable vegetation impacts, e.g. forcing a vegetation change from a mixed – grass prairie to a short – grass prairie if the drought is severe.

Plant species dynamics are also critical. Climate interacts with species life history strategies to create a range of successes for individual plant species at a site. Plant species prosper if their reproductive strategy is successful. An annual species, like cheatgrass (*Bromus tectorum*) , will thrive if a disturbance regime creates a myriad of reproductive sites for its numerous seeds to colonize. Plants with other strategies, like colonizing a site through rhizomatous spread, can become dominant after establishment. A period of drought or abundant rainfall will influence the success of individual species on specific ecological sites with considerable long-term consequences. Shrub establishment, or removal - which has been a common management technique in the past, also is important in the dynamics of grass and forb vegetation. Under certain grazing regimes, shrub cover provides a refuge for palatable species, but also create a different environment for herbaceous species to either prosper or diminish.

In summary, vegetation communities have changed with the landscape in a myriad of ways. Historical and cultural influences combine with the inherent generalization and ecological variability of ecological sites to allow a wide range of vegetation communities to occur on a given ecological site. The considerable variability that we have recorded on ecological sites that, at least in a general way, represent uniform abiotic conditions should not be unexpected. Vegetation communities themselves are not static entities but represent states that tend to persist on the landscape until disturbances and vegetation dynamics push the community to another state.

State-and-Transition Models

The state-and-transition model, now adopted by the NRCS and BLM, recognizes that alterations in plant community composition usually occur in a gradational and directional manner and may reach a point, termed a threshold, beyond which significant amounts of energy are required to return the composition to some previous point, which may not be the initial starting point. This model of community change can be conceptualized with a box-and-arrow model to represent the various seral stages and pathways possible under different disturbance types and intensities.

A recent revision and expansion (DiBenedetto et al. 2003) of an earlier draft version (Jensen et al. 1992) of a Little Missouri National Grasslands classification employs habitat types (named for climax plant association) as the primary classification unit and defines ecological types within habitat types based on abiotic modifiers, usually relating to soils but incorporating landscape variables as well. It also identifies dominance types, in effect seral stages, which are then incorporated into box-and-arrow state-and-transition models. These seral stages are based on quantitative assessment of empirical data, as recommended by Allen-Diaz and Bartolome 1998. We have modified three of the ST models of DiBenedetto et al. (2003) to accommodate our data in southeastern Montana (Appendix D).

CONCLUSION

A specific ecological site can host numerous NVCS plant associations depending on many ecological and cultural factors interacting with periodic precipitation cycles. Grazing, fire, plant species dynamics, shrub establishment or control, and weed invasion influence site conditions and the vegetation community. Additionally, the broad concept of an ecosite encompasses variation in soil texture, aspect, slope, and small-scale topography, – all of which have considerable effects on the vegetation community. In an arid region the precipitation differences inherent to our 10” – 14” study area also encompasses a range that significantly affects vegetation. We documented this ecological and cultural variability within ecosites and linked it to the rich information content of NVCS plant associations to form a template that managers can use to evaluate and predict changes in site conditions.

We found that ecosites at the extremes of the textural spectrum exhibit less variability due to the limited ecological niche for plant species. Shallow, very shallow, and gravelly ecosites were not accurately mapped in soil surveys and had vegetation more similar to plant communities found on the matrix soil texture. Landscape position within ecosite types also affected vegetation communities; strongest differences were in the sand or sandy ecosites occurring at topographic highs or lower sedimentary plains.

It is impossible to separate cultural effects (e.g. grazing) from ecological factors like climatic fluctuations or site variability without a baseline provided by well-maintained exclosures. Allen-Diaz and Bartolome (1998) state that we have good information about the process of rangeland deterioration, not recovery; what are needed are more and longer-term studies of community response. Exclosures inventoried on a 5 to 10 year cycle and located on the most common ecological sites replicated across an ecoregion would be appropriate to detect transitions (West et al. 1979, Allen-Diaz and Bartolome 1998). More exclosures are recommended to provide a monitoring baseline that can be related with the many permanent plots we established in the major ecosites.

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Appendix A. Global/State Rank Definitions

HERITAGE PROGRAM RANKS

The international network of Natural Heritage Programs employs a standardized ranking system to denote global (range-wide) and state status. Species are assigned numeric ranks ranging from 1 to 5, reflecting the relative degree to which they are "at-risk". Rank definitions are given below. A number of factors are considered in assigning ranks — the number, size and distribution of known "occurrences" or populations, population trends (if known), habitat sensitivity, and threat. Factors in a species' life history that make it especially vulnerable are also considered (e.g., dependence on a specific pollinator).

GLOBAL RANK DEFINITIONS (NatureServe 2003)

G1	Critically imperiled because of extreme rarity and/or other factors making it highly vulnerable to extinction
G2	Imperiled because of rarity and/or other factors making it vulnerable to extinction
G3	Vulnerable because of rarity or restricted range and/or other factors, even though it may be abundant at some of its locations
G4	Apparently secure, though it may be quite rare in parts of its range, especially at the periphery
G5	Demonstrably secure, though it may be quite rare in parts of its range, especially at the periphery
T1-5	**Infraspecific Taxon** (trinomial) —The status of infraspecific taxa (subspecies or varieties) are indicated by a "T-rank" following the species' global rank

STATE RANK DEFINITIONS

S1	At high risk because of extremely limited and potentially declining numbers, extent and/or habitat, making it highly vulnerable to extirpation in the state
S2	At risk because of very limited and potentially declining numbers, extent and/or habitat, making it vulnerable to extirpation in the state
S3	Potentially at risk because of limited and potentially declining numbers, extent and/or habitat, even though it may be abundant in some areas
S4	Uncommon but not rare (although it may be rare in parts of its range), and usually widespread. Apparently not vulnerable in most of its range, but possibly cause for long-term concern
S5	Common, widespread, and abundant (although it may be rare in parts of its range). Not vulnerable in most of its range

COMBINATION RANKS

G#G# or S#S#	**Range Rank**—A numeric range rank (e.g., G2G3) used to indicate uncertainty about the exact status of a taxon

QUALIFIERS

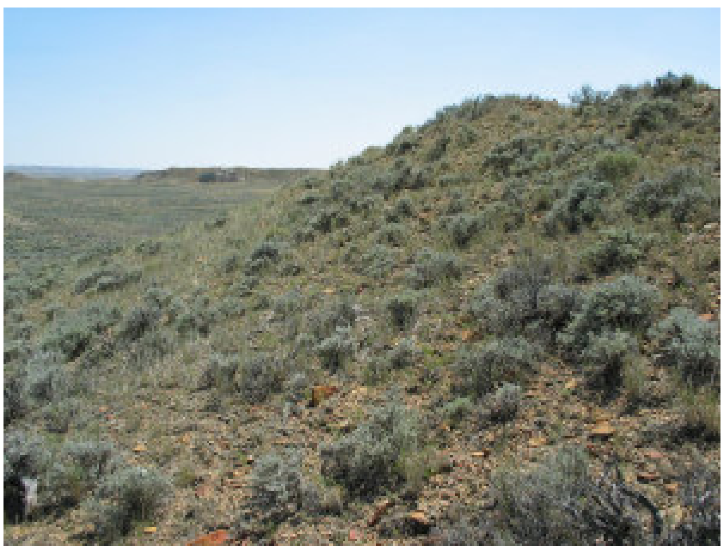
NR	Not ranked
Q	**Questionable taxonomy that may reduce conservation priority**—Distinctiveness of this entity as a taxon at the current level is questionable; resolution of this uncertainty may result in change from a species to a subspecies or hybrid, or inclusion of this taxon in another taxon, with the resulting taxon having a lower-priority (numerically higher) conservation status rank

X	**Presumed Extinct**—Species believed to be extinct throughout its range. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered
H	**Possibly Extinct**—Species known from only historical occurrences, but may never-the-less still be extant; further searching needed
U	**Unrankable**—Species currently unrankable due to lack of information or due to substantially conflicting information about status or trends
HYB	**Hybrid**—Entity not ranked because it represents an interspecific hybrid and not a species
?	**Inexact Numeric Rank**—Denotes inexact numeric rank
C	**Captive or Cultivated Only**—Species at present is extant only in captivity or cultivation, or as a reintroduced population not yet established
A	**Accidental**—Species is accidental or casual in Montana, in other words, infrequent and outside usual range. Includes species (usually birds or butterflies) recorded once or only a few times at a location. A few of these species may have bred on the one or two occasions they were recorded
Z	**Zero Occurrences**—Species is present but lacking practical conservation concern in Montana because there are no definable occurrences, although the taxon is native and appears regularly in Montana
P	**Potential**—Potential that species occurs in Montana but no extant or historic occurrences are accepted
R	**Reported**—Species reported in Montana but without a basis for either accepting or rejecting the report, or the report not yet reviewed locally. Some of these are very recent discoveries for which the program has not yet received first-hand information; others are old, obscure reports
SYN	**Synonym**—Species reported as occurring in Montana, but the Montana Natural Heritage Program does not recognize the taxon; therefore the species is not assigned a rank
*	A rank has been assigned and is under review. Contact the Montana Natural Heritage Program for assigned rank
B	**Breeding**—Rank refers to the breeding population of the species in Montana
N	**Nonbreeding**—Rank refers to the non-breeding population of the species in Montana

Appendix B. Photos

1. Clayey ecological site.

2. Claypan ecological site.

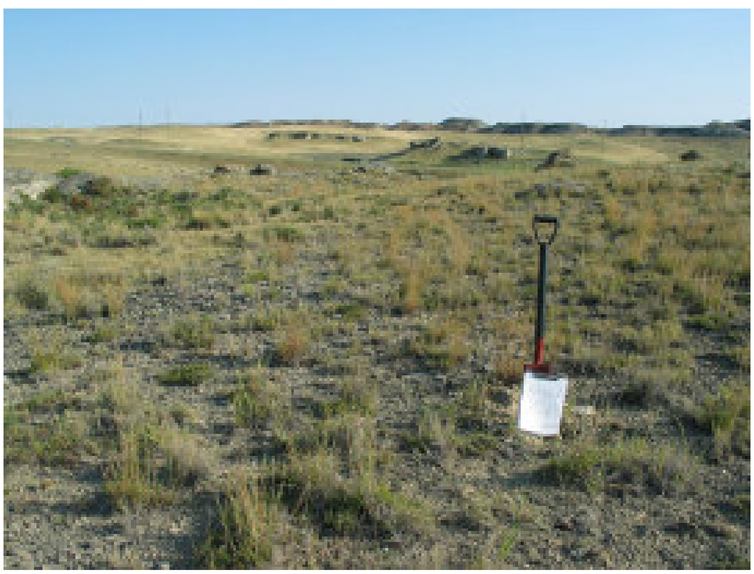


3. Thin (or steep) clayey ecological site incorrectly mapped as a shallow clay.

4. Clayey ecological site incorrectly mapped as a shallow.

5. *Clayey ecological site incorrectly mapped as a shallow.*

6. *Shallow ecological site.*



7. *Very shallow ecological site.*

8. *Overflow ecological site.*

9. *Sandy ecological site.*

10. *Thin (or steep) sandy ecological site.*

11. *Silty ecological site.*

12. *Thin (or steep) silty ecological site.*

Appendix C. Plant Association and Ecological Site Correspondence Tables

Appendix C Table 1. Plant associations and corresponding ecological sites listed by NatureServe for study ecoregion. Plots are from MTNHP and USFS studies of southeastern MT - Heidel (2001), Vanderhorst et al. (1997), Hansen and Hoffman (1988). Types with an asterisk were not listed in the study ecoregion but have been observed.

Plant Association	Element Code	#	Ecological Site
Forest Vegetation			
Acer negundo / Prunus virginiana Forest	CEGL000628		
Fraxinus pennsylvanica / Prunus virginiana Forest	CEGL000642	17	Insufficient Information to Determine
Pinus ponderosa / Mahonia repens Forest	CEGL000187		
Pinus ponderosa / Prunus virginiana Forest	CEGL000192	5	(Sy, 1); (TSy, 3); (TSi, 1)
Populus deltoides / Cornus sericea Forest	CEGL000657		
Populus tremuloides / Mahonia repens Forest	CEGL000594	4	(Sb, 3); (TSy, 1)
Populus tremuloides / Tall Forbs Forest	CEGL000618		
Woodland Vegetation			
Juniperus scopulorum / Piptatherum micranthum Woodland	CEGL000747	6	(TSi, 2); (TCy, 1): (Sw) to (St) 3
Juniperus scopulorum / Pseudoroegneria spicata Woodland	CEGL000748	4	(SwC) to (Si-St) 4
Pinus ponderosa / (Andropogon gerardii, Schizachyrium scoparium) Woodland	CEGL000641		
Pinus ponderosa / Carex inops ssp. *heliophila* Woodland	CEGL000849	3	(Sa, 1); (Sy, 1); (TSy, 1)
Pinus ponderosa / Cornus sericea Woodland	CEGL000955		
Pinus ponderosa / Crataegus douglasii Woodland	CEGL000855		
Pinus ponderosa / Festuca idahoensis Woodland	CEGL000857	2	(Sy, 1); (Si, 1)
Pinus ponderosa / Juniperus communis Woodland	CEGL000859	4	(TSy,3): (TSi, 1)
Pinus ponderosa / Juniperus horizontalis Woodland	CEGL000860	2	(TSy, 1)
Pinus ponderosa / Juniperus scopulorum Woodland	CEGL000861		
Pinus ponderosa / Pseudoroegneria spicata Woodland	CEGL000865	7	(Sw) to (St) & (Gr) 3:(Sw, 1); (TSy, 2); (SiCl, 1)
Pinus ponderosa / Schizachyrium scoparium Woodland	CEGL000201		
Populus angustifolia / Cornus sericea Woodland	CEGL002664		
Salix amygdaloides Woodland	CEGL000947		
Populus deltoides / Symphoricarpos occidentalis Woodland*	CEGL000660	2	(RSb, 2)
Quercus macrocarpa / Carex inops ssp. heliophila Woodland*	CEGL000554	1	(Cy, 1)
Quercus macrocarpa / Prunus virginiana - Symphoricarpos occidentalis Woodland*	CEGL002138	1	(Cy, 1)
Shrubland Vegetation			
Artemisia cana / Pascopyrum smithii Shrubland	CEGL001072		
Artemisia tridentata (wyomingensis?) - Atriplex confertifolian Shrubland	CEGL000993		
Artemisia tridentata ssp. vaseyana / Pseudoroegneria spicata Shrubland	CEGL001030		
Artemisia tridentata ssp. wyomingensis / Bouteloua gracilis Shrubland	CEGL001041	1	(Cy, 1)
Artemisia tridentata ssp. wyomingensis / Carex filifolia Shrubland	CEGL001042	3	(Cy, 1); (Si, 2)
Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata Shrubland	CEGL001009		
Crataegus douglasii - (Crataegus chrysocarpa) Shrubland	CEGL001093		

Table 1 - Continued

Plant Association	Element Code	#	Ecological Site
Shrubland Vegetation (Continued)			
Crataegus succulenta Shrubland	CEGL001097		
Elaeagnus commutata / Pascopyrum smithii Shrubland	CEGL001099		
Prunus virginiana - (Prunus americana) Shrubland	CEGL001108		
Rosa woodsii Shrubland	CEGL001126	1	(RM, 1)
Salix bebbiana Shrubland	CEGL001173		
Salix exigua Temporarily Flooded Shrubland	CEGL001197		
Sarcobatus vermiculatus - Artemisia tridentata Shrubland	CEGL001359		
Sarcobatus vermiculatus / Atriplex gardneri Shrubland	CEGL001360		
Sarcobatus vermiculatus / Leymus cinereus Shrubland	CEGL001361		
Sarcobatus vermiculatus / Pseudoroegneria spicata Shrubland	CEGL001367		
Shepherdia argentea Shrubland	CEGL001128		
Symphoricarpos occidentalis Shrubland	CEGL001131		
Shrub Herbaceous Vegetation			
Artemisia cana ssp. cana / Hesperostipa comata Shrub Herbaceous Vegetation	CEGL001553		
Artemisia cana ssp. cana / Pascopyrum smithii Shrub Herbaceous Vegetation	CEGL001556	12	(Si, 7); (Cy, 4); (TCy, 1)
Artemisia tridentata (ssp. tridentatata, ssp. *xericensis) / Pseudoroegneria spicata* Shrub Herbaceous	CEGL001018		
Artemisia tridentata ssp.wyomingensis / Pascopyrum smithii Shrub Herbaceous Vegetation	CEGL001047	31	(Cy, 9); (Si,15); (TSi, 2):(SiCl, 1);(CP, 1)
Artemisia tridentata ssp.wyomingensis / Pseudoroegneria spicata Shrub Herbaceous Vegetation	CEGL001535	3	(Si, 1); (TSy, 1); (TSi, 1)
Dasiphora fruticosa ssp. floribunda / Festuca idahoensis Shrub Herbaceous Vegetation	CEGL001502		
Rhus trilobata / Carex filifolia Shrub Herbaceous Vegetation	CEGL001504	4	(Sw to St, 4)
Rhus trilobata / Festuca idahoensis Shrub Herbaceous Vegetation	CEGL001505	2	(St, 2)
Rhus trilobata / Pseudoroegneria spicata Shrub Herbaceous Vegetation	CEGL001120	5	(SiSt, 3); (St, 2)
Rhus trilobata / Schizachyrium scoparium Shrub Herbaceous Vegetation	CEGL001506		
Sarcobatus vermiculatus / Pascopyrum smithii - (Elymus lanceolatus) Shrub Herbaceous Vegetation	CEGL001508	8	(Si, 2); (Cy, 4)
Yucca glauca / Calamovilfa longifolia Shrub Herbaceous Vegetation	CEGL002675	2	(Sa, 1); (TSy, 1)
Artemisia tridentata ssp. wyomingensis / Opuntia polyacantha Shrubland*		2	(Cy, 2)
Artemisia tridentata ssp. *wyomingensis / Hesperostipa comata* Shrubland*	CEGL001051	1	(Si, 1)
Schizachyrium scoparium - Bouteloua curtipendula -Bouteloua hirsuta (*Yucca glauca*) Herbaceous Veg.*	CEGL002035	3	(St, 1); (Sy, 1); (SwG, 1)
Rhus trilobata / Muhlenbergia cuspidata Shrub Herbaceous*			
Dasiphora fruticosa ssp. *floribunda / Schizachyrium scoparium* Shrub Herbaceous*	CEGL002198		
Dwarf-Shrubland Vegetation			
Artemisia pedatifida - Atriplex gardneri Dwarf-Shrubland	CEGL001525		
Atriplex gardneri - Artemisia tridentata Dwarf-shrubland	CEGL001440		
Atriplex gardneri / Pascopyrum smithii Dwarf-shrubland	CEGL001445	3	(Cy, 3)

Table 1 - Continued

Plant Association	Element Code	#	Ecological Site
Dwarf-Shrubland Vegetation (Continued)			
Juniperus horizontalis / Carex inops ssp. *heliophila* Dwarf-shrubland	CEGL001393	7	(TSy, 7)
Juniperus horizontalis / Schizachyrium scoparium Dwarf-shrubland	CEGL001394		
Krascheninnikovia lanata / Hesperostipa comata Dwarf-shrubland	CEGL001327		
Artemisia arbuscula ssp. longiloba / Pascopyrum smithii Dwarf-shrubland*	CEGL001415		
Herbaceous Vegetation			
Agrostis stolonifera Herbaceous Vegetation	CEGL001558		
Andropogon gerardii - Schizachyrium scoparium Western Great Plains Herbaceous Veg.	CEGL001463		
Andropogon hallii - Calamovilfa longifolia Herbaceous Vegetation	CEGL001467	1	(Sy, 1)
Andropogon hallii - Carex inops ssp. *heliophila* Herbaceous Vegetation	CEGL001466		
Calamovilfa longifolia - Carex inops ssp. *heliophila* Herbaceous Vegetation	CEGL001471	6	(Sa, 1); (Sy,2); (TSy, 2)
Carex nebrascensis Herbaceous Vegetation	CEGL001813		
Carex utriculata Herbaceous Vegetation	CEGL001562		
Deschampsia caespitosa Herbaceous Vegetation	CEGL001599		
Distichlis spicata Herbaceous Vegetation	CEGL001770		
Eleocharis palustris Herbaceous Vegetation	CEGL001833	1	(OV, 1)
Festuca idahoensis - Carex inops ssp. heliophila Herbaceous Vegetation	CEGL001610	8	(Sy, 4); (Si, 4)
Festuca idahoensis - Pascopyrum smithii Herbaceous Vegetation	CEGL001621		
Glyceria borealis Herbaceous Vegetation	CEGL001569		
Hesperostipa comata - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation	CEGL002037	26	(Cy, 1); (Sa, 5); (Sy, 9); (SwG, 1); (Si,8)
Hesperostipa comata - Carex filifolia Herbaceous Vegetation	CEGL001700		
Hesperostipa comata - Carex inops ssp. *heliophila* Herbaceous Vegetation	CEGL001701	7	(Sa, 1), (Sy, 5), (Si, 1)
Hordeum jubatum Herbaceous Vegetation	CEGL001798		
Juncus balticus Herbaceous Vegetation	CEGL001838		
Pascopyrum smithii - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation	CEGL001579	6	(OV, 1); (Si, 4); (Cy, 1)
Pascopyrum smithii - Distichlis spicata Herbaceous Vegetation	CEGL001580		
Pascopyrum smithii - Eleocharis spp. Herbaceous Vegetation	CEGL001581	2	(Cy, 2)
Pascopyrum smithii - Hordeum jubatum Herbaceous Vegetation	CEGL001582		
Pascopyrum smithii - Nasella viridula Herbaceous Vegetation	CEGL001583	14	(Cy, 3); (OV, 1); (Sy, 2); (Si, 6)
Pascopyrum smithii Herbaceous Vegetation	CEGL001577	5	(Cy, 4); (Si, 1)
Phalaris arundinacea Western Herbaceous Vegetation	CEGL001474		
Phragmites australis Western North America Semi-natural Herbaceous Vegetation	CEGL001475		
Poa palustris Herbaceous Vegetation	CEGL001659		
Pseudoroegneria spicata - Bouteloua curtipendula Herbaceous Vegetation	CEGL001663	3	(Tsi, 2); (SySt, 1)
Pseudoroegneria spicata - Carex filifolia Herbaceous Vegetation	CEGL001665		
Pseudoroegneria spicata - Pascopyrum smihtii Herbaceous Vegetation	CEGL001675	1	(Tsi, 1)

Table 1 - Continued

Plant Association	Element Code	#	Ecological Site
Herbaceous Vegetation (Continued)			
Pseudoroegneria spicata - Poa secunda Herbaceous Vegetation	CEGL001677		
Schizachyrium scoparium - Bouteloua (*curtipendula, gracilis*) - *Carex filifolia* Herbaceous Veg.	CEGL001581	22	(Sa 2); (Sy, 9); (Si, 4); (SiCl, 2); (TSy, 4); (TSi, 1)
Schizachyrium scoparium - Carex inops ssp. heliophila Herbaceous Vegetation	CEGL001682	2	(Si, 1); (TSy, 1)
Schizachyrium scoparium - Muhlenbergia cuspidata Herbaceous Vegetation	CEGL001683		
Schoenoplectus maritimus Herbaceous Vegetation	CEGL001843		
Schoenoplectus tabernaemontani Temperate Herbaceous Vegetation	CEGL002623		
Spartina pectinata - Carex spp. H*erbaceous Vegetation*	CEGL001477		
Spartina pectinata - Schoenoplectus Herbaceous Vegetation	CEGL001478		
Spartina pectinata Western Herbaceous Vegetation	CEGL001476	3	(RM, 1)
Sporobolus cryptandrus Herbaceous Vegetation	CEGL001514		
Calamovilfa longifolia - Carex filifolia Herbaceous Vegetation*	CEGL001470	2	(Sa, 1); (Si, 1)
Calamovilfa longifolia - Stipa comata Herbaceous Vegetation*	CEGL001473	6	(Sy, 2); (Sa, 4)
Eleocharis acicularis Herbaceous Vegetation*	CEGL001832	1	(WM, 1)
Pascopyrum smithii - Bouteloua gracilis Herbaceous Vegetation*	CEGL001578	2	(Cy, 1); (Si, 1)
Pascopyrum smithii - Buchloe dactyloides - (*Phyla cuneifolia, Oenothera canescens*) Herbaceous Vegetation*	CEGL002038	11	(Cy, 2); (Si, 10)
Pascopyrum smithii - Poa secunda Herbaceous Vegetation*	CEGLMTHP62	1	(Si, 1)
Pascopyrum smithii - Hesperostipa comata Central Mixedgrass Herbaceous Vegetation*	CEGL002034	15	(Cy, 1); (Sy, 6); (Si, 8)
Pascopyrum smithii - (*Carex stenophylla*) Herbaceous Vegetation*	CEGLMTHP61	1	(Si, 1)
Pseudoroegneria spicata - Bouteloua gracilis Herbaceous Vegetation*	CEGL001664	2	(Si, 2)
Pseudoroegneria spicata - Stipa comata Herbaceous Vegetation*	CEGL001679	2	(Sy, 2)
Puccinellia nuttalliana Herbaceous Vegetation*	CEGL001799		
Sparse Vegetation			
Artemisia longifolia - Calamovilfa longifolia Sparse Vegetation	CEGL001521		
Artemisia longifolia Sparse Vegetation*	CEGL001520	1	(SwC, 1)
Eriogonum pauciflorum - Gutierrezia sarothrae Badlands Sparse Vegetation*	CEGL005270	6	(SwC, 2); (Cy, 4)

Appendix C Table 2. Plant associations occurring on ecological site in the study area. Plots are from MTNHP and USFS studies of southeastern MT - Heidel (2001), Vanderhorst et al. (1997), Hansen and Hoffman (1988). Lifeform codes: FW = Forest or woodland; H = Herbaceous Vegetation; SV = Sparse vegetation; S = Shrubland; SH = Shrub Herbaceous; SD = Dwarf-shrubland

Ecological Site Types	Life-form	Plant Associations
Clay, Coarse (CC)		***None clearly identified***
Clay, Dense (DC)		***None clearly identified***
Clay Pan (CP)		
Clay Pan (CP)	S	*Artemisia tridentata* ssp. *wyomingensis / Pascopyrum smithii* Shrubland
Clay, Shallow (SwC)		
Clay, Shallow (SwC)	FW	*Juniperus scopulorum / Oryzopsis micrantha* Woodland
Clay, Shallow (SwC)	FW	*Juniperus scopulorum / Pseudoroegneria spicata* Woodland
Clay, Shallow (SwC)	SV	*Artemisia longifolia* Sparse Vegetation
Clay, Shallow (SwC)	SV	*Eriogonum pauciflorum - Gutierrezia sarothrae* Badlands Sparse Vegetation
Clayey (Cy)		
Clayey (Cy)	FW	*Quercus macrocarpa / Prunus virginiana - Symphoricarpos occidentalis* Woodland
Clayey (Cy)	FW	*Quercus macrocarpa / Carex inops ssp. heliophila* Woodland
Clayey (Cy)	S	*Artemisia cana /* NO FIT W/ EXISTING NVCS: Highly dist.
Clayey (Cy)	S	*Artemisia cana* ssp. *cana / Pascopyrum smithii* Shrub Herbaceous Vegetation
Clayey (Cy)	S	*Artemisia tridentata* ssp. *wyomingensis / Bouteloua gracilis* Shrubland
Clayey (Cy)	S	*Artemisia tridentata ssp. wyomingensis / Carex filifolia* Shrubland
Clayey (Cy)	S	*Artemisia tridentata ssp. wyomingensis / Opuntia polyacantha* Shrubland
Clayey (Cy)	S	*Artemisia tridentata* ssp. *wyomingensis / Pascopyrum smithii* Shrubland
Clayey (Cy)	S	*Sarcobatus vermiculatus / Pascopyrum smithii* - (*Elymus lanceolatus*) Shrub Herbaceous Vegetation
Clayey (Cy)	SD	*Atriplex gardneri / Pascopyrum smithii* Dwarf-shrubland
Clayey (Cy)	H	*Agropyron cristatum* - (*Pascopyrum smithii, Stipa comata*) Semi-natural Herbaceous Vegetation
Clayey (Cy)	H	*Bouteloua gracilis* Herbaceous Vegetation
Clayey (Cy)	H	*Pascopyrum smithii - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation
Clayey (Cy)	H	*Pascopyrum smithii - Bouteloua gracilis* Herbaceous Vegetation
Clayey (Cy)	H	*Pascopyrum smithii - Buchloe dactyloides* - (*Phyla cuneifolia, Oenothera canescens*) Herbaceous Vegetation
Clayey (Cy)	H	*Pascopyrum smithii - Eleocharis* spp. Herbaceous Vegetation
Clayey (Cy)	H	*Pascopyrum smithii - Nassella viridula* Herbaceous Vegetation
Clayey (Cy)	H	*Pascopyrum smithii - Stipa comata* Central Mixedgrass Herbaceous Vegetation
Clayey (Cy)	H	*Pascopyrum smithii* Herbaceous Vegetation
Clayey (Cy)	H	*Stipa comata - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation
Clayey (Cy)	SV	*Eriogonum pauciflorum - Gutierrezia sarothrae* Badlands Sparse Vegetation
Clayey, Thin (TCy) = Clayey Steep (CyStp)		
Clayey, Thin (TCy)	S	*Artemisia cana* ssp. *cana / Pascopyrum smithii* Shrub Herbaceous Vegetation

Table 2 - Continued

Ecological Site Types	Life-form	Plant Associations
Gravel (Gr)		
Gravel (Gr)	FW	*Pinus ponderosa / Pseudoroegneria spicata* Woodland
Meadow, Riparian (RM)		
Meadow, Riparian (RM)	S	*Rosa woodsii* Shrubland
Meadow, Riparian (RM):	H	*Spartina pectinata* Western Herbaceous Vegetation
Meadow, Wet (WM)		
Meadow, Wet (WM)	H	*Eleocharis acicularis* Herbaceous Vegetation
Overflow (OV)		
Overflow (OV)	H	*Eleocharis palustris* Herbaceous Vegetation
Overflow (OV)	H	*Pascopyrum smithii - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation
Overflow (OV)	H	*Pascopyrum smithii - Nassella viridula* Herbaceous Vegetation
Riparian Subirrigated (RSb)		
Riparian Subirrigated (RSb)	FW	*Populus deltoides / Symphoricarpos occidentalis* Woodland
Saline, Lowland (SL)		***None clearly identified***
Saline, Upland (SU)		***None clearly identified***
Sands (Sa)		
Sands (Sa)	FW	*Pinus ponderosa / Carex inops* ssp. *heliophila* Woodland
Sands (Sa)	SD	*Yucca glauca / Calamovilfa longifolia* Shrub Herbaceous Vegetation
Sands (Sa)	H	*Calamovilfa longifolia - Carex filifolia* Herbaceous Vegetation
Sands (Sa)	H	*Calamovilfa longifolia - Carex inops* ssp. *heliophila* Herbaceous Vegetation
Sands (Sa)	H	*Calamovilfa longifolia - Stipa comata* Herbaceous Vegetation
Sands (Sa)	H	*Schizachyrium scoparium - Bouteloua (curtipendula, gracilis) - Carex filifolia Herbaceous Vegetation*
Sands (Sa)	H	*Stipa comata - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation
Sands (Sa)	H	*Stipa comata - Carex inops* ssp. *heliophila* Herbaceous Vegetation
Sandy (Sy)		
Sandy (Sy)	FW	*Pinus ponderosa / Prunus virginiana* Forest
Sandy (Sy)	FW	*Pinus ponderosa / Carex inops* ssp. *heliophila* Woodland
Sandy (Sy)	FW	*Pinus ponderosa / Festuca idahoensis* Woodland
Sandy (Sy)	H	*Andropogon hallii - Calamovilfa longifolia* Herbaceous Vegetation
Sandy (Sy)	H	*Calamovilfa longifolia - Carex inops* ssp. *heliophila* Herbaceous Vegetation
Sandy (Sy)	H	*Calamovilfa longifolia - Stipa comata* Herbaceous Vegetation
Sandy (Sy)	H	*Festuca idahoensis - Carex inops* ssp. *heliophila* Herbaceous Vegetation
Sandy (Sy)	H	*Pascopyrum smithii - Nassella viridula* Herbaceous Vegetation
Sandy (Sy)	H	*Pascopyrum smithii - Stipa comata* Central Mixedgrass Herbaceous Vegetation
Sandy (Sy)	H	*Pseudoroegneria spicata - Stipa comata* Herbaceous Vegetation
Sandy (Sy)	H	*Schizachyrium scoparium - Bouteloua (curtipendula, gracilis) - Carex filifolia Herbaceous Vegetation*
Sandy (Sy)	H	*Schizachyrium scoparium - Bouteloua curtipendula -Bouteloua hirsuta* (*Yucca glauca*) Herbaceous Veg.

Table 2 - Continued

Ecological Site Types	Life-form	Plant Associations
Sandy (Sy) continued		
Sandy (Sy)	H	*Stipa comata - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation
Sandy (Sy)	H	*Stipa comata - Carex inops* ssp. *heliophila* Herbaceous Vegetation
Sandy, Thin (TSa) = Sandy, Steep (SyStp)		
Sandy, Thin (TSa)	FW	*Pinus ponderosa / Prunus virginiana* Forest
Sandy, Thin (TSa)	FW	*Populus tremuloides / Mahonia repens* Forest
Sandy, Thin (TSa)	FW	*Pinus ponderosa / Carex inops* ssp. *heliophila* Woodland
Sandy, Thin (TSa)	FW	*Pinus ponderosa / Juniperus communis* Woodland
Sandy, Thin (TSa)	FW	*Pinus ponderosa / Juniperus horizontalis* Woodland
Sandy, Thin (TSa)	FW	*Pinus ponderosa / Pseudoroegneria spicata* Woodland
Sandy, Thin (TSa)	S	*Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata* Shrubland
Sandy, Thin (TSa)	SD	*Juniperus horizontalis / Carex inops* ssp. *heliophila* Dwarf-shrubland
Sandy, Thin (TSa)	SD	*Yucca glauca / Calamovilfa longifolia* Shrub Herbaceous Vegetation
Sandy, Thin (TSa)	H	*Calamovilfa longifolia - Carex inops* ssp. *heliophila* Herbaceous Vegetation
Sandy, Thin (TSa)	H	*Schizachyrium scoparium - Bouteloua (curtipendula, gracilis) - Carex filifolia Herbaceous Vegetation*
Sandy, Thin (TSa)	H	*Schizachyrium scoparium - Carex inops* ssp. *heliophila* Herbaceous Vegetation
Shallow (Sw)	FW	*Juniperus scopulorum / Oryzopsis micrantha* Woodland
Shale (SH)		***None clearly identified***
Shallow (Sw)		
Shallow (Sw)	FW	*Pinus ponderosa / Pseudoroegneria spicata* Woodland
Shallow (Sw)	SH	*Rhus trilobata / Carex filifolia* Shrub Herbaceous Vegetation
Shallow to Gravel (SwG)		
Shallow to Gravel (SwG)	H	*Schizachyrium scoparium - Bouteloua curtipendula -Bouteloua hirsuta* (*Yucca glauca*) Herbaceous Veg.
Shallow to Gravel (SwG)	H	*Stipa comata - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation
Shallow, Very (VS)		***None clearly identified***
Silty (Si)		
Silty (Si)	FW	*Pinus ponderosa / Festuca idahoensis* Woodland
Silty (Si)	S	*Artemisia cana* ssp. *cana / Pascopyrum smithii* Shrub Herbaceous Vegetation
Silty (Si)	S	*Artemisia tridentata ssp. wyomingensis / Carex filifolia* Shrubland
Silty (Si)	S	*Artemisia tridentata* ssp. *wyomingensis / Pascopyrum smithii* Shrubland
Silty (Si)	S	*Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata* Shrubland
Silty (Si)	S	*Artemisia tridentata* ssp. *wyomingensis / Stipa comata* Shrubland
Silty (Si)	H	*Calamovilfa longifolia - Carex filifolia* Herbaceous Vegetation
Silty (Si)	H	*Festuca idahoensis - Carex inops* ssp. *heliophila* Herbaceous Vegetation
Silty (Si)	H	*Pascopyrum smithii* - (*Carex stenophylla*) Herbaceous Vegetation
Silty (Si)	H	*Pascopyrum smithii - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation
Silty (Si)	H	*Pascopyrum smithii - Bouteloua gracilis* Herbaceous Vegetation

Table 2 - Continued

Ecological Site Types	Life-form	Plant Associations
Silty (Si) continued		
Silty (Si)	H	*Pascopyrum smithii - Buchloe dactyloides* - (*Phyla cuneifolia, Oenothera canescens*) Herbaceous Vegetation
Silty (Si)	H	*Pascopyrum smithii - Nassella viridula* Herbaceous Vegetation
Silty (Si)	H	*Pascopyrum smithii - Poa secunda* Herbaceous Vegetation
Silty (Si)	H	*Pascopyrum smithii - Stipa comata* Central Mixedgrass Herbaceous Vegetation
Silty (Si)	H	*Pascopyrum smithii* Herbaceous Vegetation
Silty (Si)	H	*Pseudoroegneria spicata - Bouteloua gracilis Herbaceous Vegetation*
Silty (Si)	H	*Schizachyrium scoparium - Bouteloua (curtipendula, gracilis) - Carex filifolia Herbaceous Vegetation*
Silty (Si)	H	*Schizachyrium scoparium - Carex inops* ssp. *heliophila* Herbaceous Vegetation
Silty (Si)	H	*Stipa comata - Bouteloua gracilis - Carex filifolia* Herbaceous Vegetation
Silty (Si)	H	*Stipa comata - Carex inops* ssp. *heliophila* Herbaceous Vegetation
Silty, Coarse (SiCo)		
Silty, Coarse (SiCo)	FW	*Pinus ponderosa / Pseudoroegneria spicata* Woodland
Silty, Coarse (SiCo)	S	*Artemisia tridentata* ssp. *wyomingensis / Pascopyrum smithii* Shrubland
Silty, Coarse (SiCo)	H	*Schizachyrium scoparium - Bouteloua (curtipendula, gracilis) - Carex filifolia Herbaceous Vegetation*
Silty, Saline (SiSal)		***None clearly identified***
Silty, Stony (SiSt)		
Silty, Stony (SiSt)	H	*Pseudoroegneria spicata - Bouteloua curtipendula* Herbaceous Vegetation
Silty, Stony (SiSt)	SD	*Rhus trilobata / Pseudoroegneria spicata* Shrub Herbaceous Vegetation
Silty, Thin (TSi) = Silty Steep (SyStp)		
Silty, Thin (TSi)	FW	*Pinus ponderosa / Prunus virginiana* Forest
Silty, Thin (TSi)	FW	*Juniperus scopulorum / Oryzopsis micrantha* Woodland
Silty, Thin (TSi)	FW	*Pinus ponderosa / Juniperus communis* Woodland
Silty, Thin (TSi)	S	*Artemisia tridentata* ssp. *wyomingensis / Pascopyrum smithii* Shrubland
Silty, Thin (TSi)	S	*Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata* Shrubland
Silty, Thin (TSi)	H	*Pseudoroegneria spicata - Bouteloua curtipendula* Herbaceous Vegetation
Silty, Thin (TSi)	H	*Pseudoroegneria spicata - Pascopyrum smithii* Herbaceous Vegetation
Silty, Thin (TSi)	H	*Schizachyrium scoparium - Bouteloua (curtipendula, gracilis) - Carex filifolia* Herbaceous Vegetation
Stony (St)		
Stony (St)	SD	*Rhus trilobata / Pseudoroegneria spicata* Shrub Herbaceous Vegetation
Stony (St)	SH	*Rhus trilobata / Carex filifolia* Shrub Herbaceous Vegetation
Stony (St)	FW	*Juniperus scopulorum / Oryzopsis micrantha* Woodland
Stony (St)	FW	*Pinus ponderosa / Pseudoroegneria spicata* Woodland
Stony (St)	H	*Schizachyrium scoparium - Bouteloua curtipendula -Bouteloua hirsuta* (*Yucca glauca*) Herbaceous Veg.
Stony (St)	SD	*Rhus trilobata / Festuca idahoensis* Shrub Herbaceous Vegetation
Stream Terrace (ST)		***None clearly identified***
Subirrigated (Sb)	FW	*Populus tremuloides / Mahonia repens* Forest

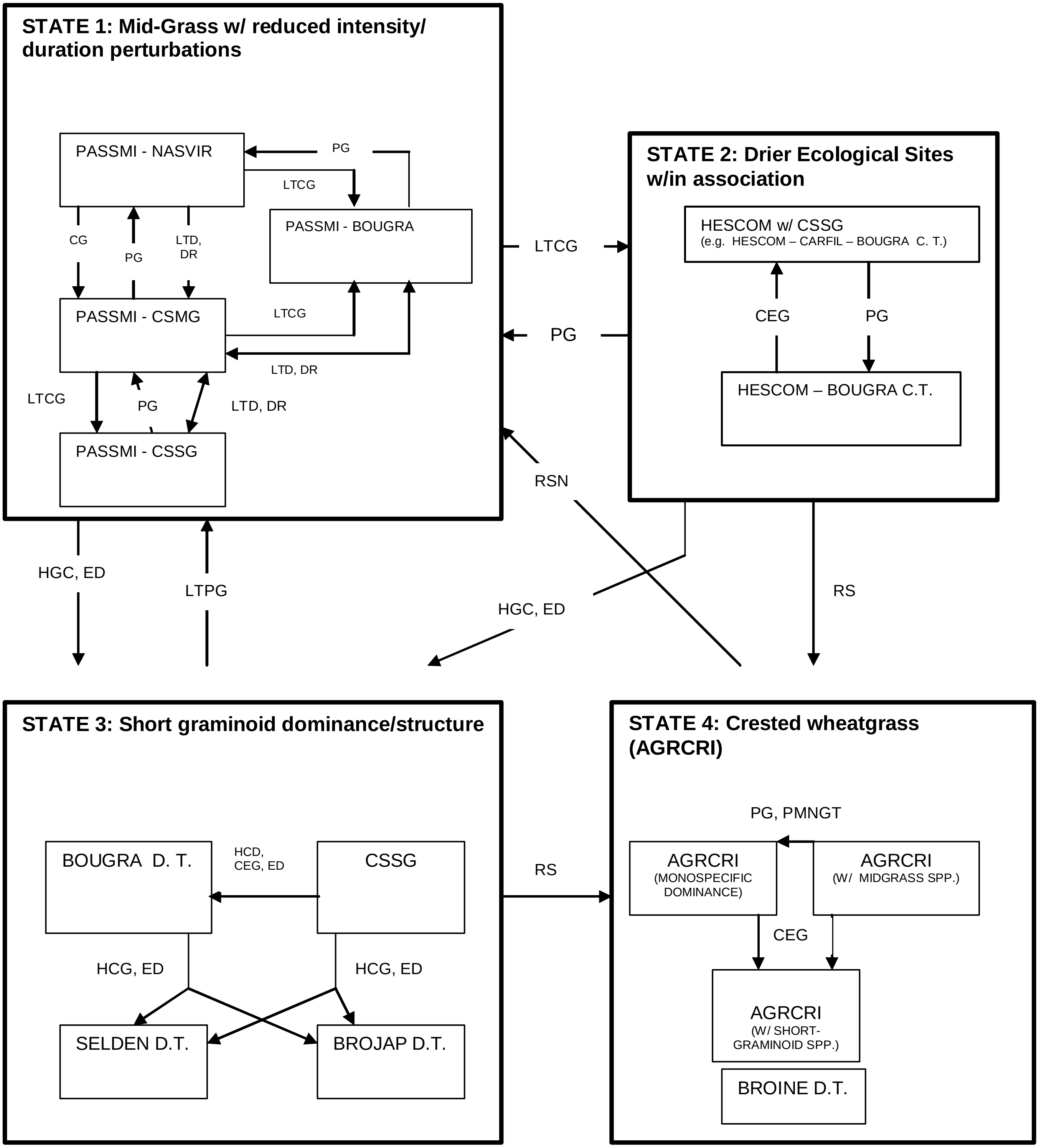
Appendix C Table 3. Species of Concern that occur within MLRA 58A.

Common Name	Scientific Name	Global Rank	State Rank	BLM Status
Baird's Sparrow	*Ammodramus bairdii*	G4	S2B	SENSITIVE
Bald Eagle	*Haliaeetus leucocephalus*	G4	S3	SPECIAL STATUS
Barr's Milkvetch	*Astragalus barrii*	G3	S2S3	WATCH
Beaked Spikerush	*Eleocharis rostellata*	G5	S2	WATCH
Beautiful Fleabane	*Erigeron formosissimus*	G5	S1	WATCH
Birchleaf Mountain-mahogany	*Cercocarpus montanus var. glaber*	G5T3T5	S1S2	WATCH
Bird Rookery	*Bird rookery*	Z	SNR	
Black-tailed Prairie Dog	*Cynomys ludovicianus*	G4	S3	SENSITIVE
Blue Sucker	*Cycleptus elongatus*	G3G4	S2S3	SENSITIVE
Bractless Mentzelia	*Mentzelia nuda*	G5	S1	WATCH
Burrowing Owl	*Athene cunicularia*	G4	S2B	SENSITIVE
Common Tern	*Sterna hirundo*	G5	S3B	
Crawe's Sedge	*Carex crawei*	G5	S2	SENSITIVE
Double Bladderpod	*Physaria brassicoides*	G5	S2	
Drummond's Hemicarpha	*Hemicarpha drummondii*	G4G5	SH	
Dwarf Woolly-heads	*Psilocarphus brevissimus*	G4	S2	WATCH
Ferruginous Hawk	*Buteo regalis*	G4	S2B	SENSITIVE
Forster's Tern	*Sterna forsteri*	G5	S2B	
Giant Helleborine	*Epipactis gigantea*	G3G4	S2	WATCH
Gray's Milkvetch	*Astragalus grayi*	G4?	S2	
Greater Sage-grouse	*Centrocercus urophasianus*	G4	S3	SENSITIVE
Interior Least Tern	*Sterna antillarum athalassos*	G4T2Q	S1B	SPECIAL STATUS
Joe-pye Weed	*Eupatorium maculatum*	G5	S2	WATCH
Large Flowered Beardtongue	*Penstemon grandiflorus*	G5?	S1	
Lead Plant	*Amorpha canescens*	G5	SH	
Loggerhead Shrike	*Lanius ludovicianus*	G4	S3B	SENSITIVE
Longleaf Dropseed	*Sporobolus asper*	G5	SH	WATCH
Meadow Jumping Mouse	*Zapus hudsonius*	G5	S2	
Merriam's Shrew	*Sorex merriami*	G5	S3	
Milk Snake	*Lampropeltis triangulum*	G5	S2	SENSITIVE
Mountain Plover	*Charadrius montanus*	G2	S2B	SENSITIVE
Musk-root	*Adoxa moschatellina*	G5	S2	WATCH
Nannyberry	*Viburnum lentago*	G5	S1	
Narrowleaf Milkweed	*Asclepias stenophylla*	G4G5	S1	WATCH
Narrowleaf Penstemon	*Penstemon angustifolius*	G5	S2	WATCH
New Jersey Tea	*Ceanothus herbaceus*	G5	SH	WATCH
Nine-anther Dalea	*Dalea enneandra*	G5	S1	WATCH
Northern Goshawk	*Accipiter gentilis*	G5	S3	SENSITIVE
Northern Redbelly X Finescale Dace	*Phoxinus eos x phoxinus neogaeus*	GNA	S3	SENSITIVE
Nuttall Desert-parsley	*Lomatium nuttallii*	G3	S1	WATCH
Peregrine Falcon	*Falco peregrinus*	G4	S2B	SENSITIVE
Persistent-sepal Yellow-cress	*Rorippa calycina*	G3	S1	WATCH

Table 3 - Continued

Common Name	Scientific Name	Global Rank	State Rank	BLM Status
Plains Phlox	*Phlox andicola*	G4	S2	WATCH
Plains Phlox	*Phlox andicola*	G4	S2	WATCH
Preble's Shrew	*Sorex preblei*	G4	S3	
Pregnant Sedge	*Carex gravida*	G5	S1	WATCH
Raceme Milkvetch	*Astragalus racemosus*	G5	S2	
Roundleaf Water-hyssop	*Bacopa rotundifolia*	G5	S1	WATCH
Sand Cherry	*Prunus pumila*	G5	S1	
Schweinitz' Flatsedge	*Cyperus schweinitzii*	G5	S2	WATCH
Scribner's Panic Grass	*Dichanthelium oligosanthes var. scribnerianum*	G5T5	S1	WATCH
Silky Prairie Clover	*Dalea villosa*	G5	S1	WATCH
Slender-branched Popcorn-flower	*Plagiobothrys leptocladus*	G4	S1	WATCH
Small Dropseed	*Sporobolus neglectus*	G5	S1	WATCH
Smooth Goosefoot	*Chenopodium subglabrum*	G3G4	S1	WATCH
Snapping Turtle	*Chelydra serpentina*	G5	S3	SENSITIVE
Spiny Softshell	*Apalone spinifera*	G5	S3	SENSITIVE
Spotted Bat	*Euderma maculatum*	G4	S2	SENSITIVE
Sturgeon Chub	*Macrhybopsis gelida*	G3	S2	SENSITIVE
Swamp Milkweed	*Asclepias incarnata*	G5	S1	
Swift Fox	*Vulpes velox*	G3	S3	SENSITIVE
Townsend's Big-eared Bat	*Corynorhinus townsendii*	G4	S2	SENSITIVE
Western Hognose Snake	*Heterodon nasicus*	G5	S2	SENSITIVE
White-bract Stickleaf	*Mentzelia montana*	G4	SH	
White-tailed Prairie Dog	*Cynomys leucurus*	G4	S1	SENSITIVE
Woolly Twinpod	*Physaria didymocarpa var. lanata*	G5T2	S1	

State & Transition Diagram:
***Pascopyrum smithii* (PASSMI) – *Nasella viridula* (NASVIR) Herbaceous Vegetation Plant Association**

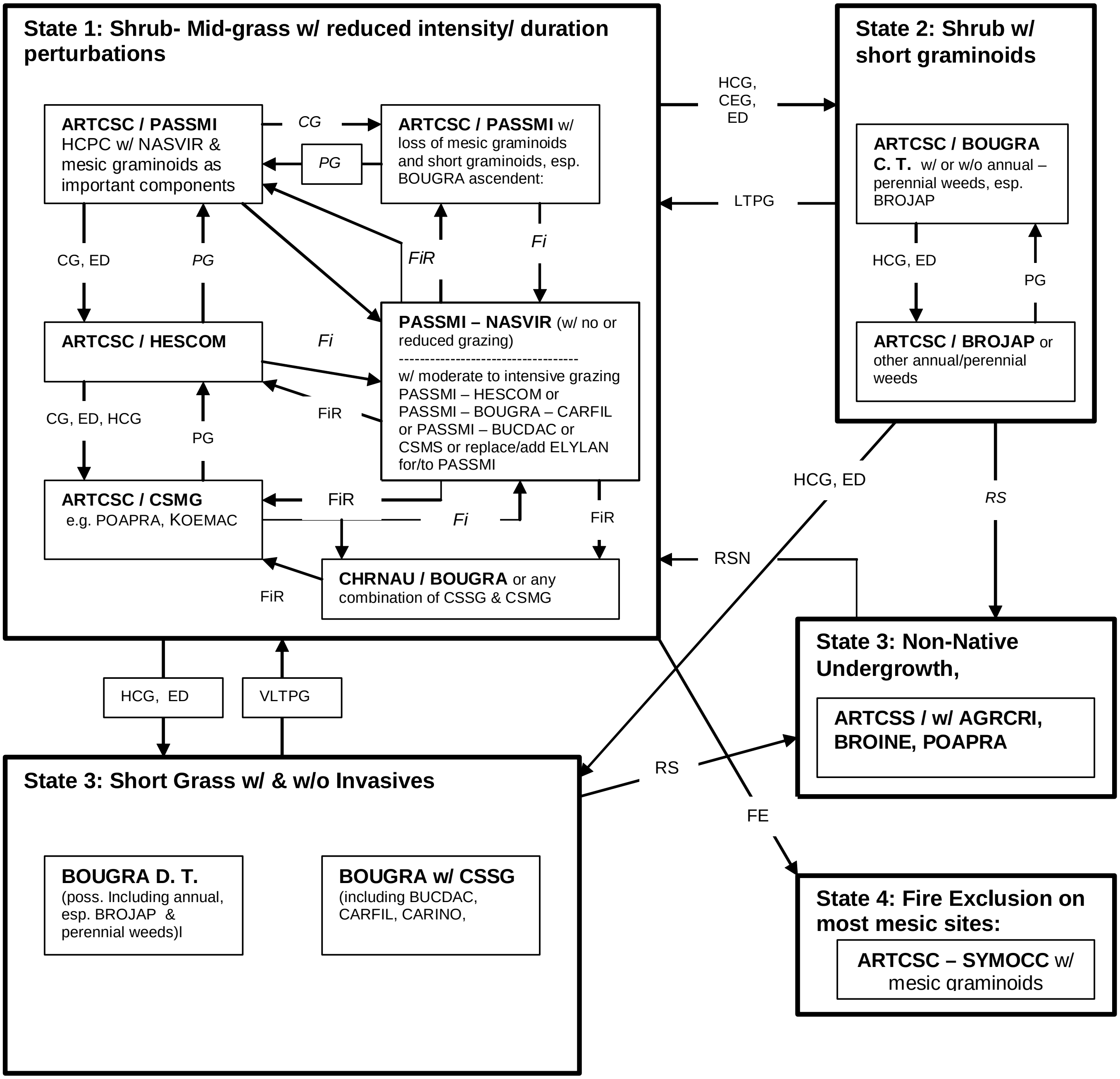


Key to abbreviations in diagram (alphabetically arranged).

CEG: Continuous early season grazing	**ED:** Excessive defoliation	**PG:** Prescribed grazing w/ adequate recovery
CG: Continuous grazing w/o adequate recovery	**HCG:** Heavy continuous grazing	**PMMGT:** Pasture management
CSMG: Cool season, mid-grasses (graminoids)	**LTCG:** Long term continuous grazing	**RS:** Range seeding, drilling
CSSG: Cool season, short graminoids	**LTD:** Long term drought	**RSN:** Range seeding w/ native graminoids
DR: Drought recovery	**LTPG:** Long term PG (> 20 yrs.)	**VLTPG:** Very long term PG (> 40 yrs.)

State & Transition Diagram:
***Artemisia tridentata ssp. wyomingensis* (ARTTSW) / *Pascopyrum smithii* (PASSMI)**
Shrubland Plant Association

Note: In any State diagram below ELYLAN can substitute for PASSMI, though they are not necessarily presumed to be ecological analogues.



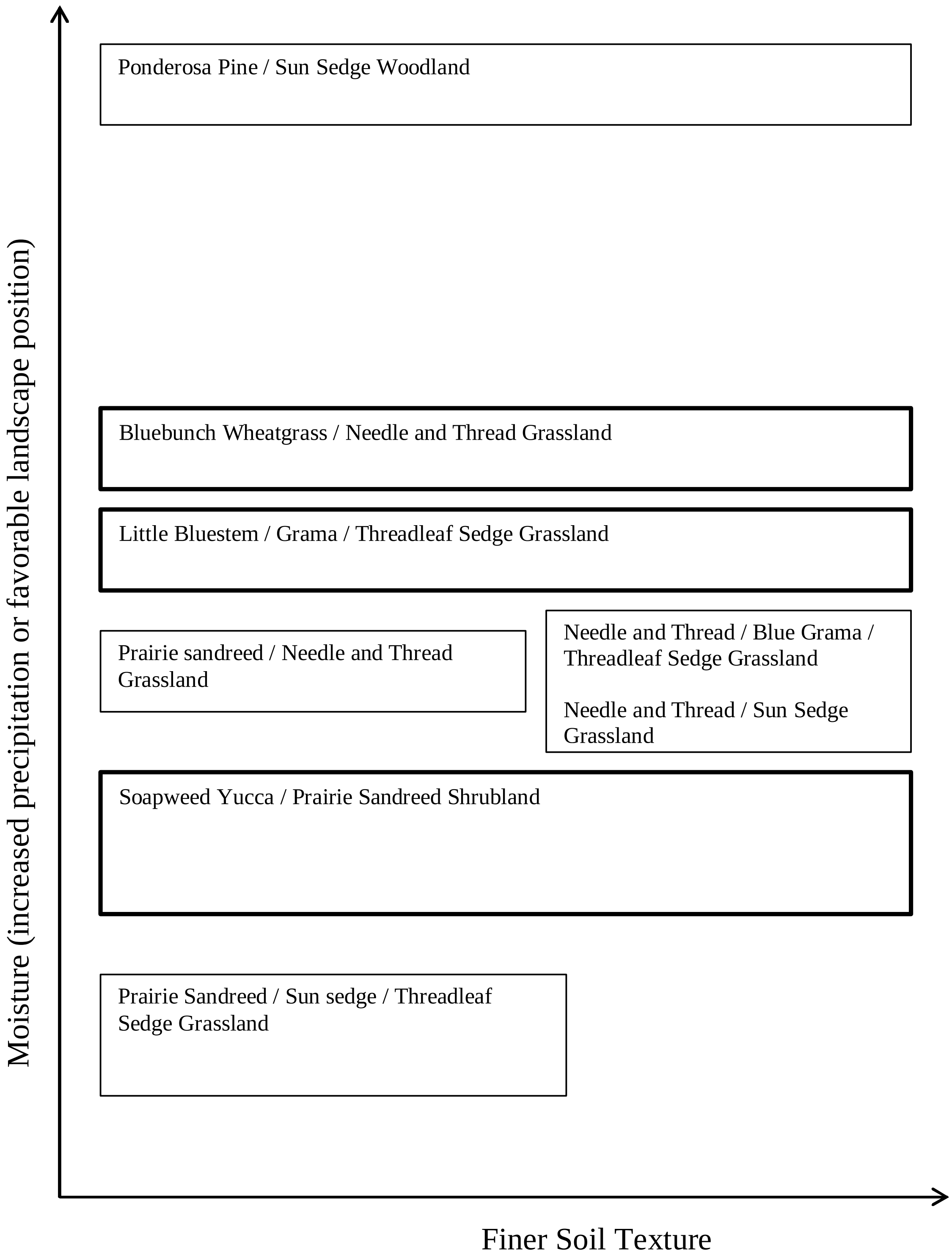
Key to abbreviations in diagram (alphabetically arranged).

CEG: Continuous early season grazing	**Fi:** Fire (wildfire & prescribed)	**PG:** Prescribed grazing w/ adequate recovery
CG: Continuous grazing w/o adequate recovery	**FE:** Fire exclusion	**PMMGT:** Pasture management
CSMG: Cool season, mid-grasses (graminoids)	**HCG:** Heavy continuous grazing	**PFiR:** Post fire recovery
CSSG: Cool season, short graminoids	**LTCG:** Long term continuous grazinng	**RS:** Range seeding, drilling
DR: Drought recovery	**LTD:** Long term drought	**RSN:** Range seeding w/ native graminoids
ED: Excessive defoliation	**LTPG:** Long term PG (> 20 yrs.)	**VLTPG:** Very long term PG (> 40 yrs.)

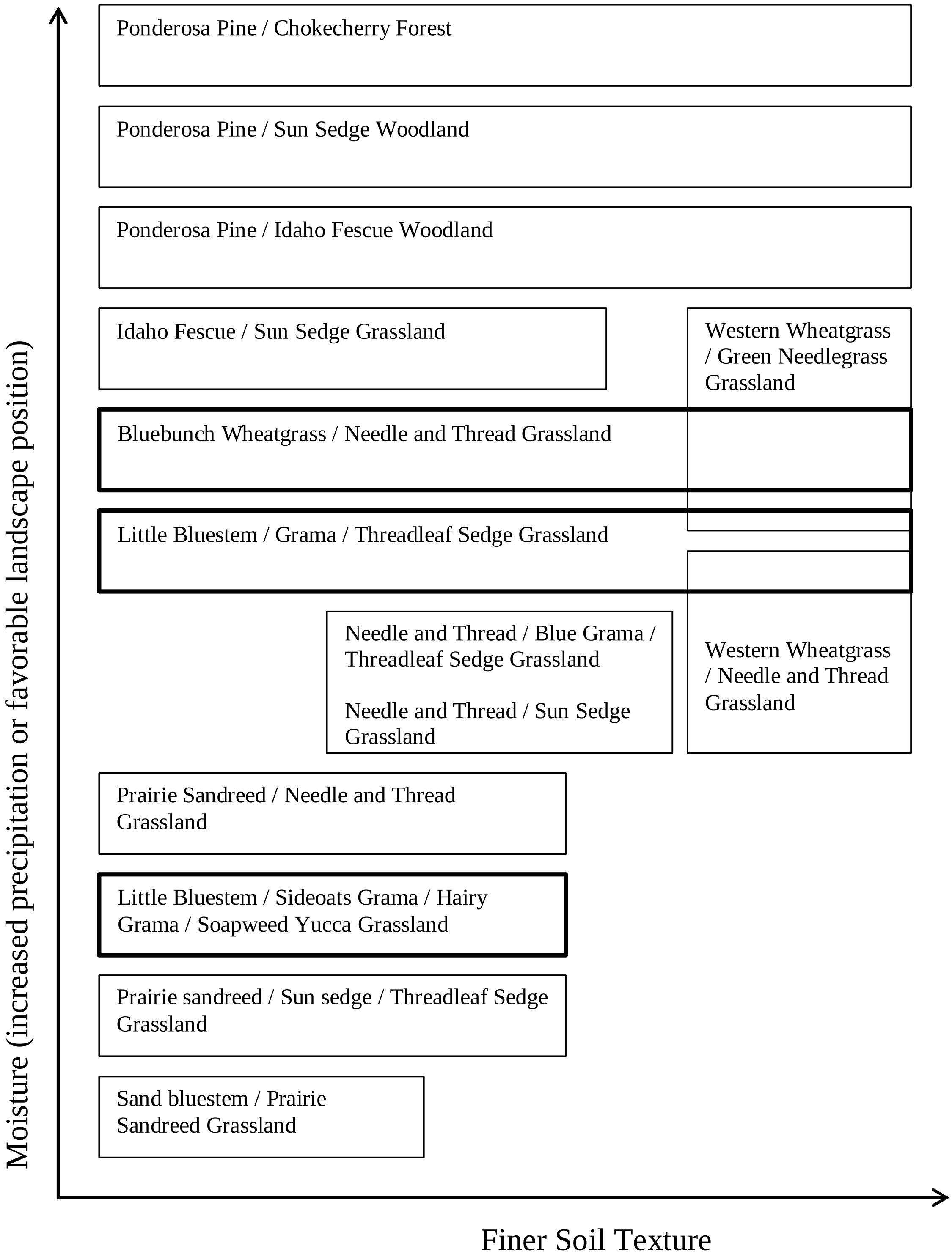
Appendix E. Relationship Diagrams of Plant Associations with Key Environmental Factors for Primary Ecological Site Groups

Boxes with bold lines indicate that slope is a primary determinant for these plant associations. Plant associations within one box occur in similar environmental settings. All plant association locations within a diagram are approximate.

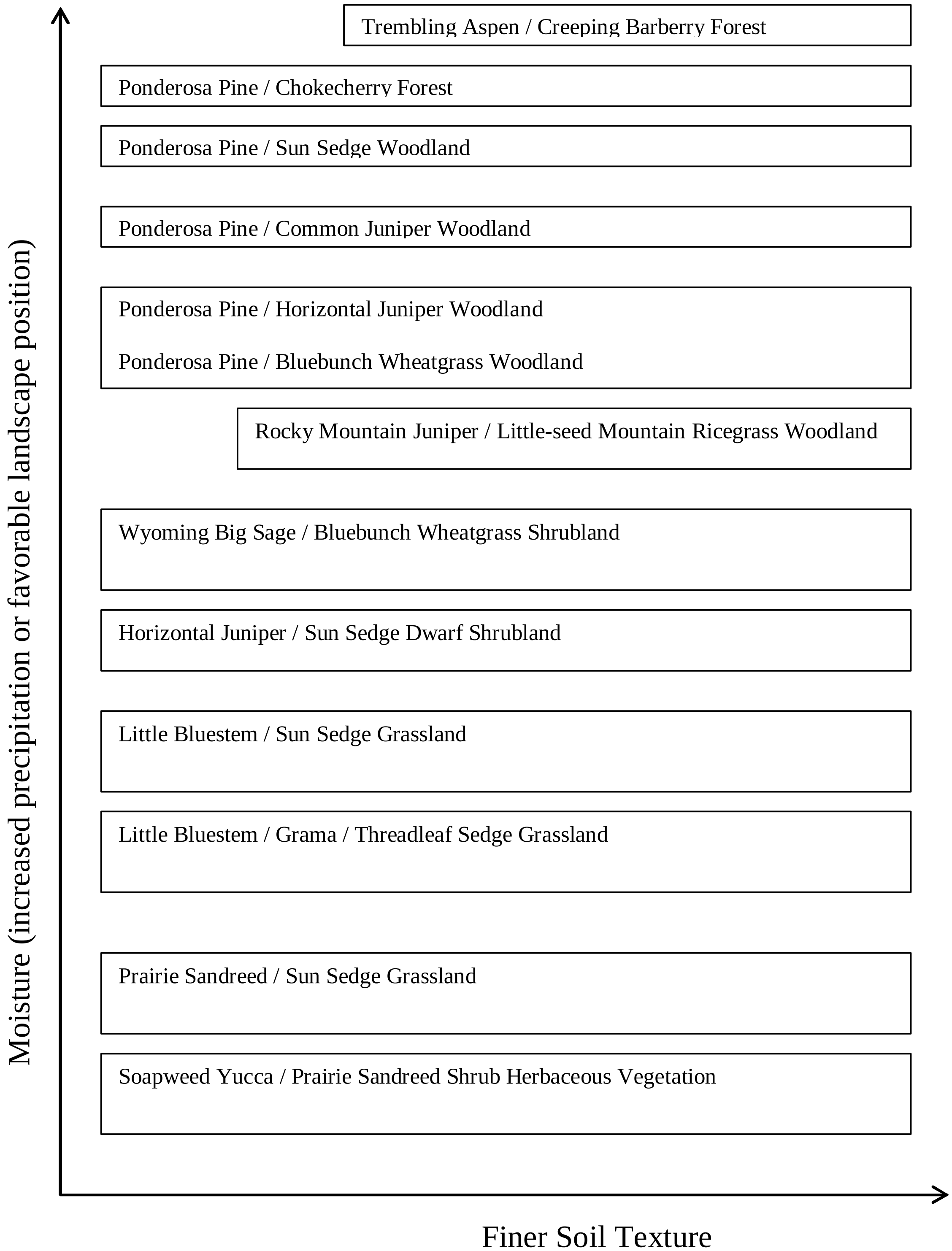
Sands Ecological Site



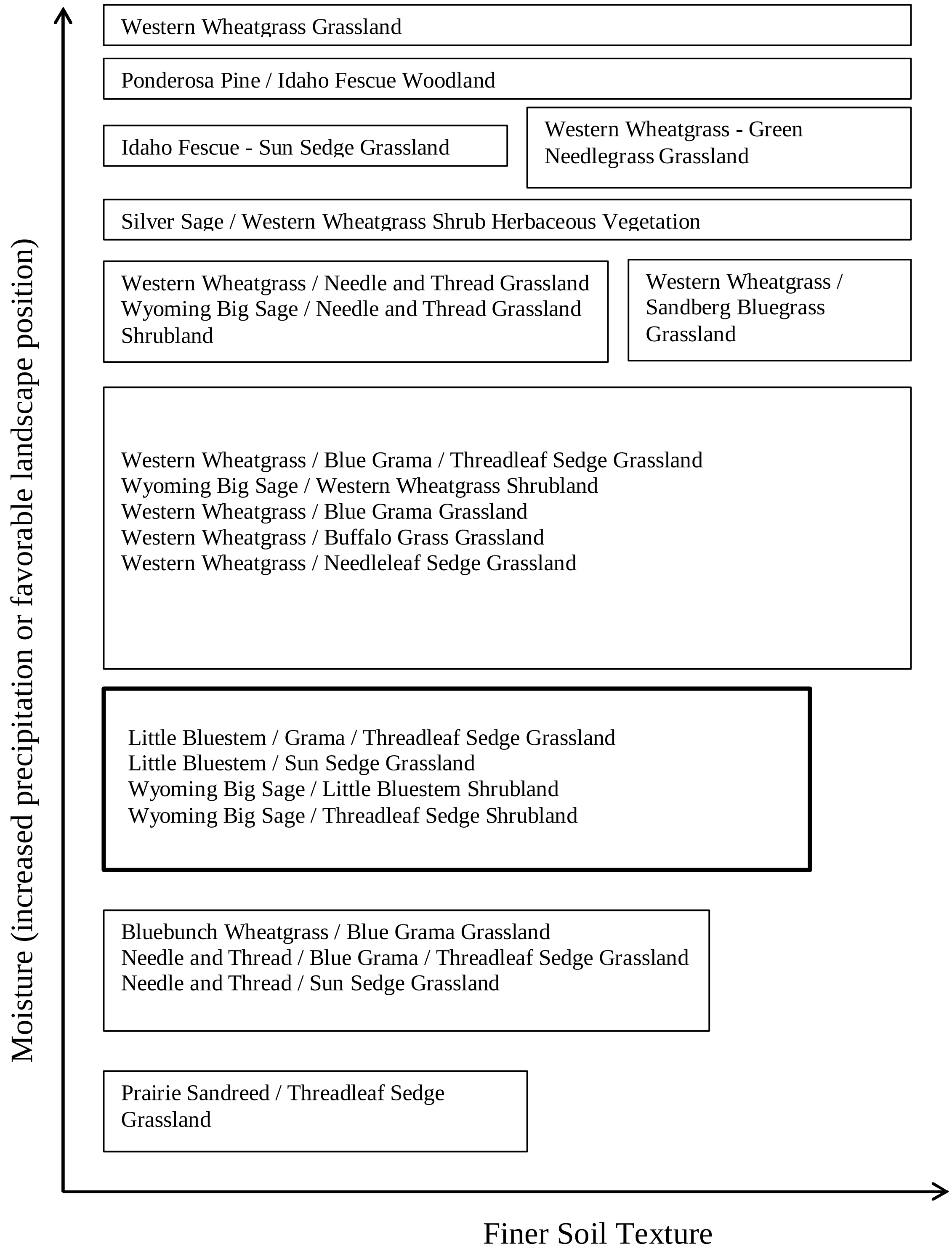
Sandy Ecological Site



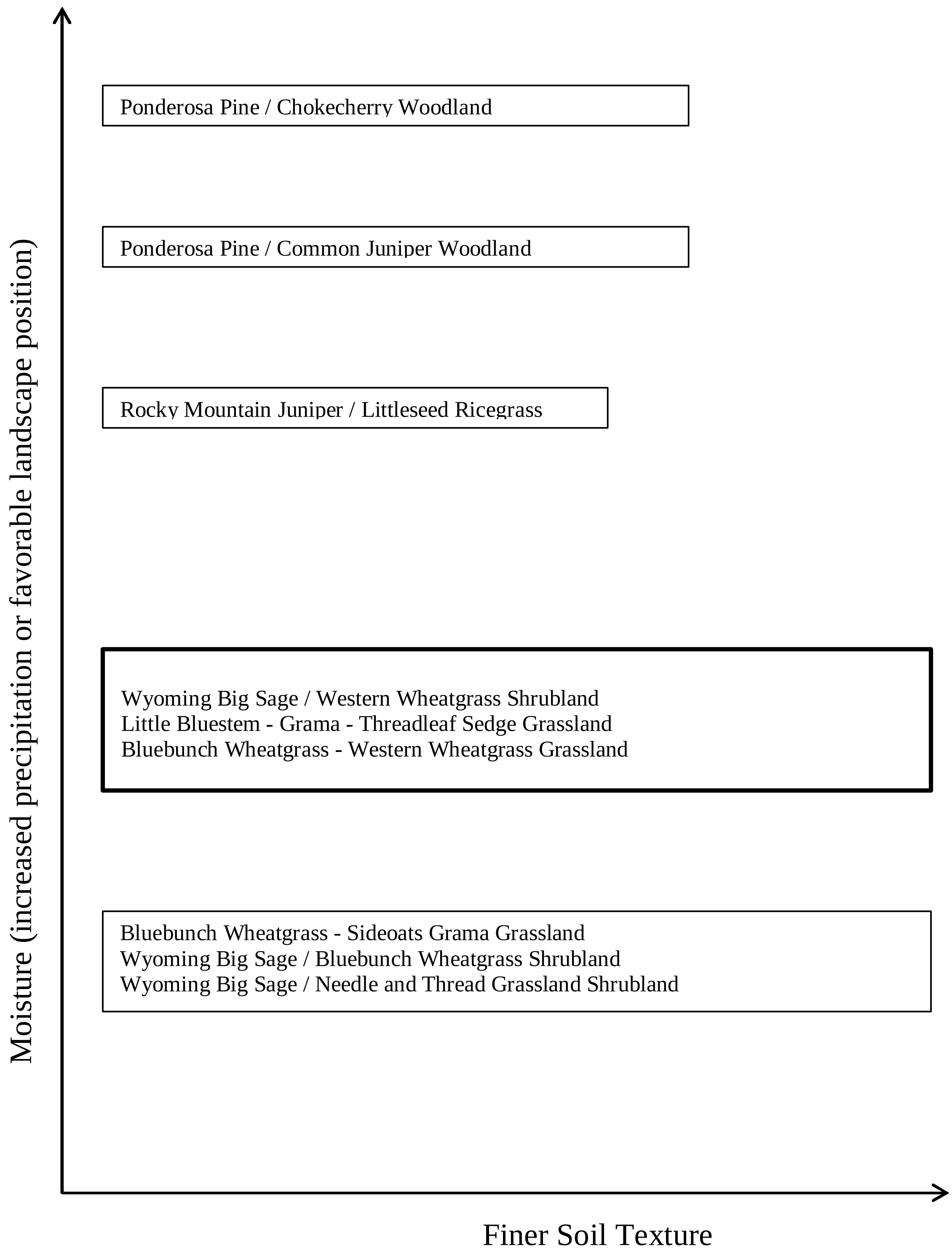
Thin Sandy Ecological Site



Silty Ecological Site



Thin Silty Ecological Site



Clayey Ecological Site